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PROCEEDINGS

FIRST CONFERENCE ON KENAF FOR PULP

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Gainesville, Florida
October 31 - November 1, 1967

First Conference

on

KENAF FOR PULP

Proceedings Compiled by
U.S. Department of Agriculture
Northern Utilization Research and Development Division
Peoria, Illinois

Sponsor

Ad hoc Committee on Kenaf and Related Raw Materials

Technical Association of the

Pulp and Paper Industry

New York, New York

Cooperators

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Northern Utilization Research and Development Division,

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October 31-November 1, 1967

Gainesville, Florida

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FOREWORD

Continually increasing consumption of pulp and paper products by an ever-expanding populace has placed unprecedented demands on the fibrous resources of the world. In some regions there are insufficient stands of suitable timber to meet these demands. In others, woods for pulping are practically nonexistent. In spite of efforts to replenish wood fiber reserves by propagation of new timber stocks and despite technological developments to extend the utility of existing fiber sources, some pulp mills are already experiencing problems in economic procurement of desirable, as well as necessary, wood species to sustain operations of the usual magnitude and quality. In some of the affected areas, commercial pulps are being produced from a variety of nonwoody fiber sources. These include such materials as sugarcane bagasse, cereal grain straws, reeds, and bamboos.

Whereas these cellulosic raw materials are capable of providing pulps of good quality, all create some problems beyond the control of a pulp mill operator. In addition, availability and cost of the residue or byproduct material may fluctuate considerably as a result of variation in magnitude of processing for the primary product.

More reliable and substantial sources of cellulosic fibers are needed. Survey studies conducted by the United States Department of Agriculture at its Northern Regional Research Laboratory have indicated that a number of plant species, not now in commercial production, have characteristics which warrant their consideration as fiber crops for pulp. Most promising of the species evaluated is kenaf, <u>Hibiscus cannabinus</u>. Its productivity in the field suggests that it might be grown solely as a crop for pulping. State and Federal agencies, as well as private industry, have been devoting considerable attention to kenaf in a continuing effort to appraise its agronomic and technologic potential. Although progress has been substantial, practical procedures for using this new pulping raw material commercially are not fully evolved. In recognition of this situation and because of a desire to expedite acceptance of this new material by industry, the <u>ad hoc</u> Committee on Kenaf and Related Raw Materials organized a technical conference on kenaf with the following objectives:

(1) To bring together for mutual benefit individuals and organizations with a common interest in the production and utilization of kenaf as fibrous raw material for pulp and paper.

(2) To provide for dissemination and exchange of available information relating to growing, soil requirements, cultural practices, harvesting, preservation, economics, and utilization in papermaking.

(3) To provide practical demonstrations of varietal characteristics and some growing, harvesting, and processing techniques.

Approximately 100 individuals representing scientific, technical, and administrative people from the pulp and paper industry, equipment manufactureres, and educational and research institutions attended the 2-day session at Gainesville, Florida, October 31-November 1, 1967. The international interest in kenaf as a promising pulp crop is indicated by the attendance of men from seven countries other than the United States.

The conferees found the meetings to be an excellent forum for free interchange of ideas. General conclusions that seem to stem from the conference proceedings are:

(1) Kenaf holds good potential as a new cellulosic crop for the pulp and paper industry. As a source of farm income, kenaf appears competitive with some pulpwoods and with several agricultural commodities in areas where its production is most likely.

(2) Opportunities exist for use of kenaf pulps alone or in blends with other fibers for paper and board manufacture.

(3) A number of problems, not insurmountable, that relate to agronomy, harvesting, preservation, and pulp treatment remain to be solved before kenaf can be accepted without reservation.

(4) Continued coordination of research effort and exchange of information will expedite solution of the unsolved problems and hasten the commercial adoption of kenaf as a source of pulp fibers.

T. F. Clark
Secretary, <u>ad hoc</u>
Committee on Kenaf and
Related Raw Materials

Peoria, Illinois
April 1968

TABLE OF CONTENTS

"SOME TRENDS IN PRODUCT DEMAND, WOOD SUPPLY AND COST
WHICH ENCOURAGE DEVELOPMENT OF NON-WOOD SOURCES
OF FIBER FOR PULPING"

by John Gray

I'd like to take this opportunity to add my own words of welcome to those of Dr. E. T. York. We are honored to have such a distinguished group of scientists and engineers from across the United States and from a number of foreign countries assembled here in Gainesville. We're delighted that our University's Center for Tropical Agriculture, Agricultural and Engineering Experiment Stations had the opportunity to cooperate with TAPPI in sponsoring this conference.

I'm glad that you are here. At the same time, I'm not certain I'm glad that I'm here--particularly since I'm expected to indicate why the time may be approaching when it will be desirable to supplement wood with Kenaf as a source of fiber for paper and paperboard manufacture. As a forester, my professional life has been at least partly dedicated to improving the efficiency of tree farming and wood processing as economic activities. For this reason, I must confess that I view this assignment with mixed emotions. One definition of "mixed emotions" goes like this: "Mixed emotions are what you feel as you watch your mother-in-law accidentally back your new Cadillac over a cliff". However, this does not exactly capture the mood of the moment. I feel rather like a Ford salesman who has been asked to give a fifteen minute talk on the subject, "Why I think my best customers are not going to keep buying more Fords," at a meeting of the research and development staff, Chevrolet Division, General Motors Corporation!

Needless to say such an assignment calls for a very high degree of objectivity!

In all seriousness, I'm not here to propagandize concerning the virtues of wood, nor to apologize for it, nor to make predictions as to whether or not its use will expand at the expense of Kenaf, or vice versa. I'm far from considering myself expert in any of the several technology or enterprise areas which would bear on making this type of forecast with any degree of precision. As a consequence, my comments will, in all probability, simply serve to remind you of certain aspects of the pulping fiber situation with which you are already familiar. Like politicians, it is the fate of most keynoters to tell people what they already know and to either "Point with Pride", or "View with Alarm", or both.

We should all feel challenged by the outlook for continued rapid growth of the pulp, paper, and paperboard industry. One of the most comprehensive appraisals of the future of this and other largely wood-based industries was developed recently by the Forestry and Forest Products Division, Food and Agriculture Organization, United Nations. Their findings were published in 1966 in a special issue of their excellent journal, "Unasylva", under the theme--"Wood: World Trends and Prospects".

Their report indicates that, over the 14 year period 1961 to 1975, annual world consumption of paper and paperboard will more than double rising from 77 to 162 million metric tons (approximately 2205 avoirdupois pounds per ton). Europe is expected to account for 33 percent of the increase; the Asian Countries, including Japan and mainland China, 24 percent; North America, 23 percent; the United States, 20 percent. United States consumption over this time period is expected to increase by 51 percent of the 1961 level.

World pulpwood yearly consumption over the same 14 years is expected to more than double also--rising from 226 to 493 million cubic meters. (1).

The predicted increases for the United States and for Northwestern Europe are of particular interest to those involved or hoping to be involved in supplying fiber raw material to pulp mills in the southern states. For example, Table 1 (see next page) shows the U. S. yearly pulpwood consumption is expected to increase by some 41 million cubic meters.

Further, this increase is expected to be met almost entirely from domestic sources with little change in the import-export balance. This amounts to an increased U.S. consumption of approximately 18,400,000 cords (1).

This prediction is extremely conservative in comparison with an estimate recently made by an economist with the American Paper Institute who expects U. S. yearly production to increase by 28 million cords over the ten years, 1965-1975 (2). It is conservative too, in light of W. S. Bromley's estimate that yearly pulpwood production in the South will increase by 10.6 million cords over the five year period, 1964-1968 (3).

The strong increase in demand predicted for Northwestern Europe will deepen that area's pulpwood deficit (Table 1). Scandinavian countries have been principally responsible for supplying the balance needed but they are facing physical limitations in terms of total available timber supply. Therefore there is a strong possibility for increased U. S. exports of chemical pulp and containerboard, particularly Kraft linerboard, to Northwestern Europe. This is of special interest to us in Florida because containerboard currently accounts for 65 percent of our paper and paperboard production (4).

TABLE 1

ESTIMATED PULPWOOD BALANCES AND NET IMPORT CHANGES

1961 and 1975

Region or Nation	Year	Million cubic meters of roundwood or round equivalent Consumption	Production	Deficit	New import change
Northwestern	1961	66	25	-41	
Europe	1975	123	34	-89	+20 to 30
Japan	1961	14	14	0	
	1975	42	32	-10	+8 to 10
United	1961	92	71	-21	
States	1975	133	111	-22	Negligible

Source - UNASYLVA, 1966.20:118-122

Briefly then, from the demand side, prospects are bright for continued substantial growth of the pulp and paper industry in the United States and the southern United States and for substantial increases in demand for sources of pulping fibers. However, some unfavorable factors are evident in the wood supply sector which, if not improved, may force the industry to consider greater use of non-wood fibers as a supplementary source of raw material.

Let me briefly identify and discuss two such factors in the time remaining. Unless otherwise indicated, my comments will be based on conditions in the southern United States.

Last year, the eleven southern states plus Oklahoma produced 33.1 million cords of wood for pulping. This amounted to nearly 61 percent of the U. S. total (5) (6).

Roughly 20 percent of the south's output last year was roundwood cut from pulp and paper company owned or leased lands. Nearly 17 percent was in the form of chips from waste material resulting from non pulp and paper, wood product manufacturing. The remaining 63 percent was roundwood purchased from non company, primarily private, individual landowners (5).

Looking backward, the 1966 production was about 2 1/2 times the yearly production in 1952. Looking forward, 1966 was the middle year of a five year period during which southern production is expected to increase by 37 percent (3).

One effect of this rapid growth has been a continually rising money price for pine and the trend has been sharpening. From 1955 to 1964, the f.o.b. pine price per cord in the southeast increased 18 percent (Table 2). I have not seen the most recent price figures but understand from friends in the industry that the current price is $19.50 per cord--a 15 percent increase in the past three years alone. These prices do not include freight costs.

This continuing upward trend in pine prices is of concern for two reasons. Wood costs are becoming a larger factor in total direct manufacturing costs per ton of pulp. For example in older southern pulp mills with relatively large labor forces, wood at a delivered cost of $20 per cord might represent one-third of direct costs per ton of unbleached Kraft pulp. In newer, more highly automated plants, wood at the same price may constitute as much as one-half of direct costs per ton. As a result, they are coming under increasing scrutiny from top management since they are playing a larger role in determining manufacturing profits (7).

A second cause for concern is the effect on the ability of the industry to compete price-wise with certain substitute products. A case in point is polyethylene plastic. Over the period 1946 to 1963, when the southeastern f.o.b. price of southern pine was increasing by $6.45 per cord (8, 9), the price of polyethylene resin to manufacturers of light weight sheets was dropping from $ .53 per pound to $ .15 to $ .20 (Table 3)--a price more than competitive with pine fibers. This has in part contributed to replacement of some paper lines by polyethylene (7).

This continuing rise in money prices paid for outside wood is one unfavorable factor then in the wood supply picture.

The second one I want to identify relates to land requirements, and land cost as an input in growing industrial wood crops.

Although efforts are going forward on many fronts to improve wood production per acre of land, the fact is inescapable that the growing of industrial wood crops, even under intensive management by today's standards, requires very large amounts of land and capital. Further, the pulp and paper industry has not as yet been able to realize yields on capital so invested at levels considered acceptable for investments of comparable risk.

John A. Segur, former Vice President-Treasurer of Riegel Paper Corporation, presented a very interesting analysis of these factors in a recent issue of the "Journal of Forestry". Mr. Segur estimates a capital investment of $128 per acre in fully stocked, planted southern pine under sustained yield managment on land of average site quality. He further estimates that 530 such acres, representing a total capital investment of $68,000, are required to supply the wood fiber needed annually per ton of daily capacity for a southern bleached Kraft pulp mill. He estimates the net income per acre after taxes at $3.50--a return of 2.8 percent on invested capital (10).

Under the most favorable land and timber productivity circumstances encountered in his experience, 290 acres, representing a land investment of $41,000 per ton of daily mill capacity, would be required with the timber activity earning a net return after taxes of 5 percent on invested capital (10).

By contrast, the mill investment is estimated at $75,000 per ton of daily capacity on which an after tax return of 10 percent on capital is expected (10).

The money cost of acquiring and owning land, like the money price for southern pine pulpwood, appears to be continually increasing. I have no data

TABLE 2

PINE PULPWOOD PRICES
SOUTHEASTERN UNITED STATES

Year	Rough Pine Roundwood Delivered Price Per Cord	
1955	$14.35	
1959	$16.00	+18%
1964	$17.00	

Source - Southeastern Forest Experiment Station, Forest Service, U.S. Dept. of Agric.

TABLE 3

WOOD FIBERS VS. POLYETHYLENE

Cost to Converters

Low density polyethylene resin: (from petroleum and natural gas sources)

1946 — $ .53 per lb.

1963 -- $ .15 to $ .20 per lb.

Wood pulp fibers

1963 -- $ .06 to $ .10 per lb.

Source - Changing Markets and Natural Resources, M. H. Collet, V. P. Olin Mathieson, Paper at 1964 Annual Mtg., Amer. Pulpwood Assn.

on trends in forest land prices in the south. However, farmland values per acre which have risen by $70 an acre or more in two southern regions since 1960 (see Table 4) may be considered indicative in my judgment.

Further the cost of owning land is rising. From 1960 to 1966, average ad valorem taxes on timber land in 25 north Florida counties rose from $ .29 to $ .72 per acre accompanying a more than fivefold increase in assessed values, according to a study conducted by the Florida Forestry Association.

Since land requirements to provide the wood fiber necessary to support a daily ton of manufacturing capacity are high in comparison to land required to provide equivalent Kenaf fiber, new mills, or mills undergoing expansion, may well find it advantageous to include Kenaf in their fiber mix in the future.

In summary:

--There is substantial evidence that world consumption of paper and paperboard products will more than double over the period 1961 to 1975.

--U. S. pulp, paper and board producers may face not only an expanding domestic market, but also an opportunity to export steadily increasing amounts of chemical pulp and containerboard to Northwestern Europe through the rest of this century.

--In the southern United States, a number of factors indicate that it may be difficult to provide a substantial increase in wood fiber raw material at acceptable prices or earnings on capital invested in land and tree farming. As a result, the industry may exhibit greater and greater interest in possibilities for supplementing wood with non-wood fibers such as Kenaf. This may be particularly necessary for new mills with an inadequate land base trying to establish fiber raw material supply systems in areas of moderate to intense competition for available wood.

TABLE 4

AVERAGE VALUE OF FARMLAND

	Per Acre Values		
Year	Southeast (S.C., Ga., Fla., Ala.)	Delta (Miss., Ark., La.)	U.S. (48 Continental States)
1960	$133	$124	$116
1966	$203	$196	$157
Increase	$ 70	$ 72	$ 41
1966/1960	1.53	1.58	1.35

Source - *Farm Real Estate Market Developments*, Economic Research Service, U.D. Dept. of Agric., CD-68, July, 1966, page 18

Corn Belt and Pacific Coast were only other regions showing increases of $70 per acre or more.

References Cited

(1) "Wood: World Trends and Prospects", Unasylva 20 (1-2) Numbers 80-81: (1966)

(2) Paykin, Bentley H. "Fiber Mix Seen Changing through 1975", Pulp and Paper 40(24) : (June 13, 1966)

(3) Bromley, William S. "Southern Pulpwood Explosion", Pulpwood Production and Sawmill Logging 14 (2) : (February, 1966)

(4) Slatin, Benjamin. "Marketing Wood Products: Paper and Paperboard", Unpublished paper presented at 1967 Annual Meeting, Florida Forestry Association, Orlando, Florida : (October, 1967)

(5) "A Statistical Report on the Pulp and Paper Industry in the South", Southern Pulpwood Conservation Association folder: (1967)

(6) "Value of 1966 Pulpwood Harvest in the South Reaches a Record High of $661.2 Million", Southern Pulpwood Conservation Association news release: (October 2, 1967)

(7) Collet, M. H. "Changing Markets and Natural Resources", paper presented at 1964 Annual Meeting, American Pulpwood Association, New York, New York : (February, 1964)

(8) "Pulpwood Price Trends in the Southeast", Research Notes, Southeastern Forest Experiment Station, No. 136: (November, 1959)

(9) "Pulpwood Prices in the Southeast, 1963". U. S. Forest Service Research Note SE-28 : (July, 1964)

(10) Segur, John A. "Protecting Our Wood Supply", Journal of Forestry 65(7): (July, 1967)

SESSION ON PRODUCTION, HARVESTING AND ECONOMICS: SUMMARY REMARKS

George A. White, Chairman

Summaries of individual and panel presentations from this session are given herein. In most cases complete manuscripts were not prepared, and some of the reported information was preliminary and part of research still in progress. Pertinent references are given at the end of summaries. Mention of equipment names is for information and does not constitute a recommendation over similar type equipment. Likewise, mention of pesticides does not constitute a recommendation for use. An overall summary of the session follows.

Summary

Kenaf is a very promising annual source of pulping raw material for the Southeast. Dry-matter yields as high as 20 tons per acre have been obtained on an experimental plot basis. Yields of 7 to 10 tons per acre appear quite feasible on a large-scale basis. Although productive varieties are available, intensive breeding research is needed to develop varieties that are both nematode resistant and distinctly suited for pulping purposes. Root-knot nematodes (Meloidogyne spp.) are unquestionably the most serious production pests. Several 1967 plantings were severely damaged by heavy infestions. Resistant varieties represent the best answer to the problem and methods to obtain resistance were described. An economic potentiality assessment for selected Southeastern areas indicates that kenaf should be competitive with corn and soybeans but not cotton for acreage. Further studies should be conducted on weed control, fertility, pH tolerances, and timing and methods of harvesting. Yield data from plantings large enough for use of regular planting and harvesting equipment are needed. This data should encompass two or more years. Through leaf development studies at Glenn Dale, Md., a method has been devised to predict yields for different areas. The prediction method makes use of temperature data for the selected areas. These predictions should serve as reliable guides to probable yields in areas where kenaf has not been tested. Existing forage choppers especially the cylinder type are suitable for harvesting kenaf but slight modifications and increased capacity would be preferred. Depending upon climatic conditions, kenaf may be harvested and stored either in an air-dry or high-moisture state. Dewatering and anaerobic storage studies are in progress. The ensilability and digestibility of young kenaf plants (about 6 feet tall) compared favorably with that of other popular silage crops in Florida. The removal of the upper 24 inches of plants that are being harvested for pulp appears desirable. This leafy nitrogenous portion which contributes little to the pulp yield could either be returned to the soil or used for feed if suitable collecting and handling procedures were developed.

KENAF BREEDING

By F. D. Wilson

Breeders of kenaf (*Hibiscus cannabinus* L.) have released varieties that are quick-growing and high yielding, that have high bast-fiber content, resistance to anthracnose (caused by *Colletotrichum hibisci* Poll.), and desirable characteristics for mechanical harvesting and processing. They have also developed strains with varying photoperiodic requirements to extend the harvest season and the effective ecological range of the crop.

Breeders have made little progress, however, in developing varieties resistant to root-knot nematodes (*Meloidogyne* spp.) and associated root-rot organisms because of the lack of genetic variability in cultivated kenaf. Susceptibility to nematodes and root-rot fungi thus remains the most serious problem in kenaf culture in areas where these organisms are prevalent. Breeders and pathologists followed four lines of endeavor, as follows: (1) selected for resistance within cultivated lines; (2) attempted to transfer resistance from a wild relative of kenaf, *Hibiscus acetosella* Welw. ex Hiern, either directly, through an allohexaploid bridge, or through a third bridging species; (3) screened wild strains of kenaf, then crossed the resistant wild with the susceptible cultivated strains; (4) synthesized a new fiber-plant species by crossing resistant roselle (*Hibiscus sabdariffa* L.) with susceptible kenaf, followed by spontaneous doubling of the chromosome number of the hybrid. The first two lines of research were followed exhaustively with little result; the last two were in an early stage when the kenaf breeding program in southern Florida was discontinued.

Past breeding objectives emphasized the development of kenaf as a bast-fiber crop (fiber extracted from the bark, wood fibers not used), rather than as a pulp crop. Practical limitations on the size of field decorticators and ribboners encouraged the development of rapidly maturing plants that grew well in dense stands, that had stems of small diameter (high bark/wood ratio), and that were not too tall. Seeds were planted in late spring to ensure plants that were not too large to be harvested when fiber quality was highest (flowering stage).

In the development of kenaf as a pulp crop, some of the original breeding objectives will remain the same, such as resistance to root-knot nematodes and associated fungi, and to the anthracnose organism. Other objectives, however, will change. For example, the most desirable pulp variety may be one which is cold tolerant and resistant to early seedling diseases; thus allowing seed to be planted in early spring. It may also be one in which

plants will remain vegetative throughout the growing season and will produce maximum yields of dry matter before killing frosts. The optimum wood/bark ratio in a pulping variety may be quite different from that in a bast-fiber variety. Finally, characteristics such as intervarietal differences in pulping properties must be considered in a breeding program designed to improve kenaf as a source of paper pulp.

References

1. Wilson, F. D. Econ. Bot., 21(2): 132. 1967.

2. Wilson, F. D. and Menzel, M. Y. Econ. Bot., 18(1): 80. 1964.

3. Wilson, F. D. and Summers, T. E. Phytopath., 56(6): 678. 1966.

4. Wilson, F. D., Summers, T. E., Joyner, F. F., Fishler, D. W., and Seale, C. C. Florida Agr. Expt. Sta. Circular S-168. 12 pp. 1965.

ECONOMICS OF KENAF FOR PULP IN THE SOUTH: A PRELIMINARY VIEW

By Warren K. Trotter* and Ray S. Corkern

The South is recognized as the nations leading pulpwood producing region. Twelve Southern states in 1966 supplied 61% of the nations pulpwood requirements (1). Timber growth in the South amounts to nearly half of the U.S. total, although only 39% of the nation's commercial forest land is located in the region. The region is fortunate in having a climate and species of timber which give a high rate of growth compared to other timber producing areas of the country. It is the most favored section of the country in terms of timber growth rate, accessability of supply, and availability of labor to harvest the crop.

What, then, is the need for kenaf in this important pulpwood producing region? Let us examine this question briefly before considering the economics of kenaf as a pulping raw material for the South.

Although the South is fortunate in having large timber resources, an unprecedented expansion in pulpwood demand in recent years is placing increased pressure of the areas available supply. During 1966 alone, five new pulp mills went into operation in the South and by the end of the year 11 more new mills were under construction (1). The rapid growth in pulpwood consumption is illustrated in Figure 1. The slope of this curve indicates an average rate of increase of 6.4% compounded annually for the period 1950 and 1966.

U.S. Forest Service projections indicate that unless forest management is intensified the volume of timber cut for all purposes in the South may equal timber growth by about 1990 and will be substantially in excess of growth by the year 2000 (3). More recent data indicate pulpwood consumption is substantially above the projection used in this study (4). Thus, the volume cut may exceed growth at an even earlier date than Forest Service projections indicate.

Some areas in the South already have reached the limit of their ability to sustain continued growth in pulp production (5). Any increase in production of pulpwood in these areas with intensified forest management could deplete growing stock and jeopardize the areas future supply. For mills in these areas to expand production, additional sources of raw materials will be needed.

The rapidly expanding Southern pine plywood industry represents additional competition for the South's timber resources. Production of Southern pine plywood has been projected as high as 7 billion sq. ft. by 1975 (6).

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* Presented by Warren K. Trotter

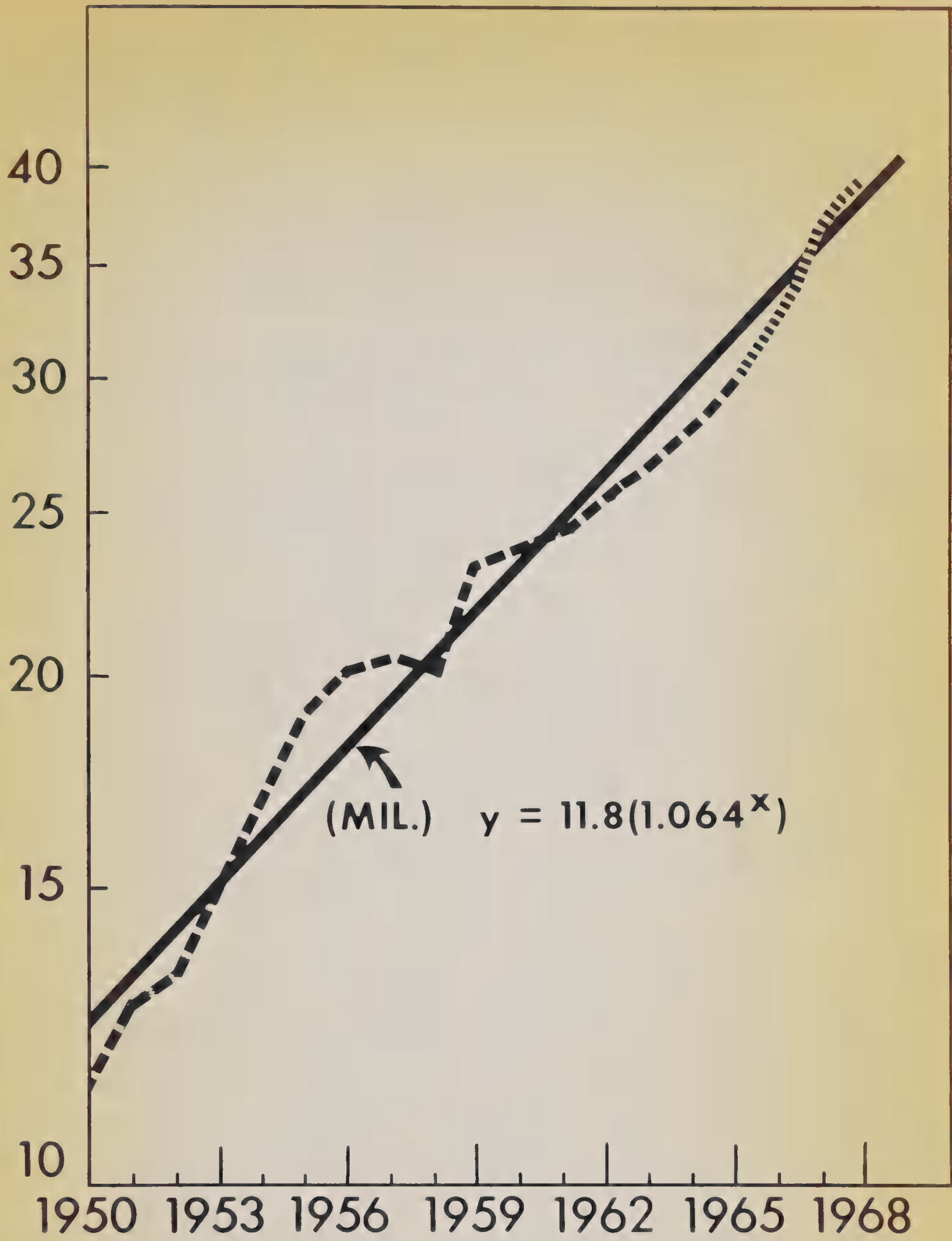
[illegible] in the South, and by the end of the year [illegible] (1). [illegible] The slope of this curve [illegible] figure.

[illegible] will increase in the South [illegible] grow which will be substantially in excess of [illegible] data [illegible] above the projection used in this study (1). Thus, the [illegible] growth [illegible]

[illegible] in the South trend [illegible] and the [illegible] of that [illegible] growth in pulp and paper (2). The increase in [illegible] in those areas [illegible] and [illegible] other [illegible] tics, and allied [illegible]

The expansion [illegible] plus pine [illegible] in the South [illegible] through the [illegible] be 7 million [illegible] 1975 (6).

[illegible]



SOURCE: ADAPTED FROM BROMLEY (2) 1966-68 PROJECTED

Fig. 1. Trend in pulpwood consumption in the South.

Other factors which bear on the future supply of plywood in the South include such things as the diversion of forest acreage to recreational and water reservoir uses, increased concern over the world food crisis, urban expansion and increasing costs of pulpwood stumpage and harvesting.

A high proportion of the South's commercial forest acreage belongs to small owners. These owners have shown little interest in the improvements in timber management practices necessary to increase timber growth (3). This lack of interest may result from the low returns per acre from timber compared to some annual farm crops. Estimated annual returns per acre above certain specified expenses for three timber species with different rotation periods are shown in Table I. These estimates assume good timber managment practices on good open sites. No charge was made for the use of land or for taxes and interest on operating capital. So, in reality, the net returns above all costs would be somewhat lower than those shown.

Because of the low return per acre, timber commands a low priority as an alternative use of agricultural land in the South. Kenaf is a potential pulp raw material offering the possibility of better returns per acre than timber production and comparable to other annual crops.

Estimated cost of producing and harvesting kenaf

We have attempted to develop data that would provide a measure of the economic feasibility of kenaf as a papermaking raw material. Cost estimates for producing and harvesting kenaf were constructed from available data on cost of performing the different operations involved. These data for the most part were obtained from state experiment station reports giving cost data on established crops for a number of farming areas in the South. It should be emphasized that these estimates at this stage in the development of kenaf should be viewed as first approximations. Optimum methods for producing and harvesting kenaf as a pulp crop have not been fully established and cost data based on actual experience with kenaf are not yet available.

For purposes of this analysis we have viewed kenaf as a crop to be grown on regular commercial farms although we recognize that it may be more advantageous to grow it on a larger scale than would be possible with the typical farm operation. Cost estimates were developed representing 10 farming areas in the South (Figure 2). Three of these areas are in Texas, 2 in Mississippi, 1 in Alabama, 3 in Georgia, and 1 in South Carolina.[1/] These areas were selected because cost and returns data were available for established crops and because they represent a range of farming conditions found in the South.

1/ Although Northern Florida appears to have good potential for producing kenaf, this area was not included because suitable data was not available on established crops. The Northern Florida area should be roughly comparable to the S.W. Coastal Plain area of Georgia and Alabama.

Fig. 2. Location of selected farming areas in the South.

Table I.--Estimated present value of annual returns above specified expenses for selected timber species[a]

Species and rotation	Present value of average annual returns per acre with discount rate of[b]:		
	4%	6%	8%
Cottonwood:			
30-year rotation	$ 6.72	$3.99	$1.77
42-year rotation	7.31	3.70	1.12
Loblolly pine:			
35-year rotation	3.52	2.26	1.38
50-year rotation	13.90	8.57	5.25
Shortleaf pine:			
35-year rotation	3.22	3.06	1.25
50-year rotation	7.48	4.25	2.33

[a] Established on good open sites with good timber management practices in the Yellow Creek Watershed of Mississippi. Based on 1963 prices. Specified expenses were: Trees, tractors and equipment, and labor for planting and pruning.

[b] Estimated returns from timber cover a period of years extending into the future and must be discounted at the going rate of interest, or rate of return on investment, to make them comparable to estimated returns from annual crops.

Source: Williams and Hunt (26).

For each farming area, estimates were developed for two farm situations: (1) Harvesting performed with regular farm-owned forage harvesting equipment, and (2) harvesting performed by a custom operator or contractor using large-scale forage harvesting equipment. The custom operator's equipment was a large, high-volume forage harvester which probably could not be justified for an individual farm operation.

In each area estimates were developed for three levels of yield per acre. Cultural practices, yields of established crops, and physical input data were adapted from published state experiment station reports covering each of the farming areas (7-20). Because cultural practices, machinery and equipment varied from one area to another, the cost estimates also vary. The procedure for estimating kenaf production and harvesting costs is illustrated in Table II, using the Piedmont area of Georgia as an example.

Estimated costs of producing and harvesting kenaf in the remaining nine farming areas were computed in a similar manner (Table III). These estimated costs per ton varied from $8.36 in the Central Blackland Prairie of Texas (with a yield of 10 tons per acre) to $14.70 per ton in the Upper Coastal Plain of South Carolina (with a yield of 6 tons per acre).

Our cost estimates do not include a charge for irrigation. In certain areas, or during certain seasons, irrigation may be necessary and would add to production costs.

If harvesting is done with large-scale equipment, such as might be used by a custom operator or possibly by the paper mill, total costs may be somewhat lower than shown in Table III. Estimates shown in Table IV are based on the use of large-scale harvesting and hauling equipment not considered practical for an individual farm operation.[2]

Value of kenaf at mill

The value of kenaf delivered to a pulp mill would depend upon several factors. Most important of these would be the cost of competing raw materials, particularly pulpwood. It would also depend on: (1) The yield of pulp that can be obtained from kenaf; (2) the quality of pulp produced, or its suitability for a given end-use, in comparison to woodpulp; and (3) the costs of storage, handling, and processing kenaf relative to pulpwood.

Studies carried out at the Northern Regional Research Laboratory[3] indicate the yield of pulp from oven-dry kenaf should be reasonably comparable to

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[2] The operating cost of this equipment was estimated from data in the 1967 Agricultural Engineers Handbook (21).

[3] A laboratory of the Northern Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture, Peoria, Illinois

Table II.--Estimated cost of producing and harvesting kenaf with regular farm-owned forage harvesting equipment, Piedmont area of Georgia[a]

Cost item	Cost per acre with yield of[b]:		
	6 tons	8 tons	10 tons
Production cost:			
Seed (8 lbs. at $.40)	$ 3.20	$ 3.20	$ 3.20
Fertilizer[c]	18.70	18.70	18.70
Lime	2.74	2.74	2.74
Machinery and equipment	5.90	5.90	5.90
Labor	5.00	5.00	5.00
Land charge[d]	8.65	8.65	8.65
Taxes[e]	.68	.68	.68
Interest on operating capital[f]	1.38	1.38	1.38
Sub-Total	46.25	46.25	46.25
Production cost per ton	7.71	5.78	4.62
Harvesting costs:			
Machinery and equipment	$11.10	$12.95	$14.80
Labor	3.83	4.47	5.11
Hauling to paper mill[g]	24.00	32.04	39.96
Sub-Total	38.93	49.46	59.87
Harvesting cost per ton	6.49	6.18	5.99
Total cost per acre	85.18	95.71	106.12
Total delivered cost per ton	14.20	11.96	10.61

[a] Production costs are based on 1966 prices. The cultural practices and physical input data were adapted from published state reports (7-20) and vary among the ten farming areas studied.

[b] Oven-dry basis

[c] Fertilizer rate: 5 cwt. 4-12-12 and 2.4 cwt. ammonium nitrate. This rate is slightly higher than the rate used for corn in the Piedmont area.

[d] Six percent of 1964 average price of farm land in area adjusted to 1967 price level by the annual index of farm land prices.

[e] Based on tax rate per acre as reported in the Agricultural Finance Review.

[f] Six percent of 1/2 of annual operating expanse.

[g] Based on cost of operating a 2 1/2 tons truck and 20 mile haul and assuming a 70 percent moisture content for green kenaf.

Table III.--Estimated cost of producing and harvesting kenaf with regular farm-owned forage harvesting equipment in selected farming areas of the South

State and farming area	Delivered cost per ton with yields per acre of[a]		
	6 tons	8 tons	10 tons
<u>Alabama</u>:			
Wiregrass	$12.94	$11.09	$ 9.98
<u>Georgia</u>:			
North Georgia	14.07	11.87	10.54
Piedmont	14.20	11.96	10.61
Southwest Coastal Plain	14.24	12.00	10.64
<u>Mississippi</u>:			
Black Belt	14.00	11.90	10.62
Brown Loam	13.58	11.58	10.37
<u>South Carolina</u>:			
Upper Coastal Plain	14.70	12.37	10.96
<u>Texas</u>:			
Lower Rio Grande Valley	12.62	10.69	9.53
Central Blackland Prairie	10.67	9.24	8.36
Coastal Plains	12.60	10.68	9.52

[a] Oven-dry basis

Table IV.--Estimated cost of producing and harvesting kenaf with large-scale harvesting equipment, selected farming areas of the South

State and farming area	Delivered cost per ton with yields per acre of[a]:		
	6 tons	8 tons	10 tons
Alabama:			
Wiregrass	$11.43	$ 9.78	$ 8.78
Georgia:			
North Georgia	13.18	11.09	9.83
Piedmont	13.31	11.18	9.90
Southwest Coastal Plain	13.35	11.22	9.93
Mississippi:			
Black Belt	12.50	10.58	9.41
Brown Loam	12.07	10.26	9.16
South Carolina:			
Upper Coastal Plain	13.57	11.38	10.06
Texas:			
Lower Rio Grande Valley	12.36	10.48	9.33
Central Black Prairie	10.43	9.03	8.17
Coastal Plains	12.36	10.47	9.33

[a] Oven-dry basis

yields obtained from most species of pulpwood. Pilot-scale studies on well-preserved kenaf gave yields of 45 to 48% screened sulfate pulp (22). Yields ranging from 45 to 54% are reported for major hardwood and softwood species (23,24). There is need for more complete data to show the influence on pulp yield of prolonged storage under different conditions.

With respect to pulp quality, the studies at the Northern Laboratory on well-preserved material show sulfate kenaf pulps have properties that should make them more desirable than hardwood pulps for many purposes, and suitable for many applications where softwood pulps are now used (22,25).

A preferred system for storing and handling kenaf after harvest to maintain raw material quality remains to be developed. Several possible techniques are being considered and it appears likely that satisfactory methods can be developed. However, because kenaf is produced seasonally and is bulky, storage and handling costs may be somewhat higher for kenaf than for pulpwood. On the other hand, cost of processing kenaf may be somewhat lower than for pulpwood, especially in a mill designed specifically for kenaf pulping. Consumption of chemicals and power to process kenaf should be less than that required to process pulpwood.

If we assume that yield and quality of pulp and costs of storing, handling and processing kenaf are roughly comparable to those for pulpwood, then chopped kenaf on an oven-dry basis delivered to pulp mills should be approximately equivalent in value to wood chips at the mill less byproduct credits. However, if prolonged storage should adversely affect pulp yield or quality, or if storage and processing costs should significantly exceed those for wood this value relationship would change. Technical studies now underway should provide more insight on these questions.

Estimated costs of wood chips at pulp mills in the South in 1967 were approximately \$22 per ton of oven-dry wood for pine and \$17 per ton for hardwood (Table V).[4/] With respect to pine, limited data from industry sources indicate by-product credits may reduce this cost by as much as \$3 per ton of dry wood, leaving a net raw material cost of around \$19 per ton. Thus, under our assumptions above, the value of chopped kenaf on an oven-dry basis delivered to mills should be in the range of \$17 to \$19 per ton.

Price needed for kenaf

If kenaf is to be grown by farm operators in the South it should yield a return at least comparable to other crops now grown. Representative net returns from cotton, corn, and soybeans in 10 farming areas ranged from a loss of \$10.25 per acre on corn in the Wiregrass area of Alabama to a high of \$109.60 per acre for cotton in the Brown Loam area of Mississippi (Table VI). Returns were generally highest for cotton while corn and soybeans were about equal.

4/ These estimates are based on prices of rail roundwood which accounts for about half of all wood receipts at pulp mills in the region (2).

Table V.--Trends in pulpwood prices in the South, 1962-1966.

Class of pulpwood and year	Dollars per cord f.o.b. rail car[a]	Cost per ton of dry wood at mill, debarked and chipped[b]
<u>Pine</u>:		
1962	16.25	19.46
1963	16.15	19.38
1964	16.50	19.67
1965	17.50	20.50
1966	18.55	21.38
1967	19.50	22.17
<u>Hardwood</u>:		
1962	12.90	15.15
1963	12.75	15.04
1964	13.35	15.48
1965	14.50	16.33
1966	14.95	16.67
1967	15.50	17.07

[a] Price f.o.b. railroad at spur or siding (<u>27</u>). 1967 prices estimated by authors.

[b] Price per cord f.o.b. rail car converted as follows: Average rail freight to mill--$3.50 per cord; dry wood per cord--2,400 pounds pine and 2,700 pounds hardwood; debarking and chipping cost--$3.00 per ton of dry wood.

Table VI.--Estimated net returns per acre for cotton, corn and soybeans in selected farming areas of the South[a]

State and area	Cotton	Corn	Soybeans
	----------- Dollars -----------		
Alabama:			
Wiregrass	10.50	–10.25	11.95
Georgia:			
Southwest Coastal Plains	46.14	2.65	10.75
North Georgia	---	25.82	---
Piedmont	30.49	– 3.73	12.84
Mississippi:			
Brown Loam	109.60	26.23	18.43
Black Belt	80.19	14.30	29.90
South Carolina:			
Upper Coastal Plains	66.81	6.47	24.04
Texas:			
Lower Rio Grande Valley	47.89	---	---
Central Blackland Prairie	5.25	---	---
Coastal Prairie	41.81	47.08	---
Average:	48.74	13.57	17.98

[a] Cotton returns based on 1966 prices plus support payments; corn and soybean returns based on average prices for 1964-66. Cultural practices, yields and costs based on published state experiment station reports (7-20).

Assuming regular farmer-owned harvesting equipment and kenaf yields of 6, 8 and 10 tons per acre, then the price needed for kenaf to equal returns from corn ranged from $9.98 per ton in the Wiregrass area of Alabama to $20.44 in the Coastal Prairie of Texas (Table VII). Using large-scale harvesting equipment the range in price needed for kenaf would be $8.78 to $20.20. Similar comparisons can be made for soybeans and cotton (Tables VIII and IX).

On the basis of these estimates and under the assumptions we have used it seems that kenaf should be able to compete with corn or soybeans in most of the farming areas considered. It appears less able to compete with cotton.

Economic benefits of establishing kenaf

There are a number of benefits that would accrue to the South from commercialization of kenaf as a papermaking raw material. One of these would be a more complete utilization of the agricultural resources of the area. There is substantial crop land, or potential crop land, not now being fully utilized that could be used for kenaf as well as pulpwood. This could be done without displacing crops now grown. There is also a surplus of farm labor in certain sections of the South. The opportunities kenaf may provide for rural development should be fully explored. Production of kenaf would provide a base for expanding the pulp and paper industry beyond that possible with existing timber resources. The added income from successful commercialization of kenaf would accrue to all segments of the South's economy--the farm community, the pulp and paper industry and the general business community, as well.

There are, of course, still many unanswered questions. We believe the economics of kenaf for pulp appear sufficiently promising to justify the expanded research necessary to provide answers.

Table VII.--Estimated price per ton required of kenaf to equal net returns from corn in selected farming areas of the South

State, farming area and type harvesting equipment	Price required with kenaf yields per acre (dry basis) of: 6 tons	8 tons	10 tons
Alabama:			
Wiregrass area:			
Regular	$12.94[a]	$11.09[a]	$ 9.98[a]
Large-scale	11.43[a]	9.78[a]	8.78[a]
Georgia:			
North Georgia area:			
Regular	18.38	15.10	13.12
Large-scale	17.49	14.32	12.41
Piedmont:			
Regular	14.20[a]	11.96[a]	10.61[a]
Large-scale	13.31[a]	11.18[a]	9.90[a]
Southwest Coastal Plain:			
Regular	14.68	12.33	10.90
Large-scale	13.79	11.55	10.19
Mississippi:			
Black Belt:			
Regular	16.39	13.68	12.05
Large-scale	14.88	12.36	10.84
Brown Loam:			
Regular	17.96	14.86	12.99
Large-scale	16.44	13.54	11.78
South Carolina:			
Upper Coastal Plain:			
Regular	15.78	13.18	11.60
Large-scale	14.65	12.19	10.70
Texas:			
Coastal Prairie:			
Regular	20.44	16.57	14.23
Large-scale	20.20	16.36	14.04

[a] Break-even price of kenaf; net return from corn was negative.

Table VIII.--Estimated price per ton required of kenaf to equal net returns per acre from soybeans in selected farming areas of the South

State, farming area and type harvesting equipment	Price required with kenaf yields per per acre (dry basis) of:		
	6 tons	8 tons	10 tons
Alabama:			
Wiregrass area:			
Regular	$14.93	$12.59	$11.18
Large-scale	13.42	11.27	9.97
Georgia:			
Piedmont area:			
Regular	16.34	13.57	11.90
Large-scale	15.45	12.79	11.18
Southwest Coastal Plain:			
Regular	16.03	13.34	11.71
Large-scale	15.14	12.56	11.00
Mississippi:			
Black Belt:			
Regular	18.99	15.63	13.61
Large-scale	17.48	14.31	12.40
Brown Loam:			
Regular	16.66	13.88	12.21
Large-scale	15.14	12.56	11.00
South Carolina:			
Upper Coastal Plain:			
Regular	18.70	15.37	13.36
Large-scale	17.58	14.39	12.46

Table IX.--Estimated price per ton required of kenaf to equal net returns per acre from cotton in selected farming areas in the South

State, farming area and type harvesting equipment	Price required with kenaf yields per acre (dry basis) of:		
	6 tons	8 tons	10 tons
<u>Alabama</u>:			
Wiregrass area:			
Regular	$14.69	$12.41	$11.03
Large-scale	13.18	11.09	9.82
<u>Georgia</u>:			
Piedmont:			
Regular	19.28	15.78	13.66
Large-scale	18.38	15.00	12.95
Southwest Coastal Plain:			
Regular	21.93	17.76	15.25
Large-scale	21.04	16.99	14.54
<u>Mississippi</u>:			
Black Belt:			
Regular	27.37	21.92	18.64
Large-scale	25.86	20.60	17.43
Brown Loam:			
Regular	31.85	25.28	21.33
Large-scale	30.34	23.96	20.12
<u>South Carolina</u>:			
Upper Coastal Plain:			
Regular	25.83	20.72	17.64
Large-scale	24.71	19.74	16.74
<u>Texas</u>:			
Lower Rio Grande Valley:			
Regular	20.59	16.68	14.32
Large-scale	20.34	16.46	14.12
Central Blackland Prairie:			
Regular	11.55	9.90	8.89
Large-scale	11.31	9.68	8.70
Coastal Prairie:			
Regular	19.57	15.91	13.70
Large-scale	19.32	15.70	13.51

LITERATURE CITED

1. U.S. Forest Service, "Southern Pulpwood Production-1966," SO-9, (1967).

2. Bromley, W. S., Pulpwood Production and Saw Mill Logging, 14(2): 12, 14, 16, 20, 22, 24, 26 (February 1966).

3. U.S. Forest Service, "Timber Trends in the United States," Forest Resource Report No. 17, (February 1965).

4. U.S. Forest Service, "The Demand and Price Situation for Forest Products-1966," (January 1967).

5. Spier, W. B., Southern Pulp and Paper Manufacturer, (April 10, 1966).

6. Battelle Memorial Institute, "Preliminary Technical-Economic Evaluation of Wood Adhesives...," Research Report for the Iowa Development Commission, (March 1967).

7. Moore, D. S., and Rogers, R. H., "Production and Production Requirements, Costs and Expected Returns for Crop Production, on Well-Drained Clay and Clay Loam Soils, Coastal Prairie of Texas," Texas Agricultural Experiment Station, MP 756, February 1965.

8. Hatch, Roy E., Tefertiller, K. R., Moore, D. S., and Rogers, R. H., "Production and Production Requirements, Costs and Expected Returns, Cotton, Grain Sorghum and Major Fresh Market Vegetable Crops on Clay Soils--Lower Rio Grande Valley of Texas," Texas Agricultural Experiment Station, MP 694, (February 1964).

9. Freeman, Billy G., Rogers, R. H., and Moore, D. S., "Production and Production Requirements, Costs and Expected Returns for Crop and Livestock Enterprises, Rolling Backland Soils of the Central Blackland Prairie of Texas," Texas Agricultural Experiment Station, MP 752, (January 1965).

10. Members of the Delta Subcommittee, "Budgets for Major Farm Enterprises in the Mississippi River Delta of Arkansas, Louisiana, and Mississippi," AEC. MR. No. 30, (June 1961).

11. Jones, Gary C., Strickland, Jr., P. L., and Partenheimer, E. J., "Minimum Open Land Requirements for $5,000 Farm Income, Wiregrass Area (Lower Coastal Plains) Alabama," Agricultural Experiment Station of Auburn University, Alabama, AE 6, (July 1965).

12. Tramel, Thomas E., Keenan, Walter E., and Vanderford, Harvey B., "Normal Yields and Production Practices by Soil Types, Mississippi, Black Belt Area," Mississippi Agricultural Experiment Station, Bulletin 731, (October 1966).

13. Tramel, T. E., and Long, J. T., "Power and Equipment Costs in the Brown Loam Area of Mississippi," Mississippi Agricultural Experiment Station, Bulletin 688, (May 1964).

14. Tramel, T. E., Keenan, W. E., and Vanderford, H. B., "Normal Yields and Production Practices by Soil Types, Mississippi Brown Loam Area," Mississippi Agricultural Experiment Station, Bulletin 704, (March 1965).

15. Crecink, J. C., "Budgets for Major Farm Enterprises in the Clay-Hills of Mississippi," Mississippi Agricultural Experiment Station, AEC, MR. No. 45, (March 1965).

16. Steanson, O., Saunders, F. B., and McArthur, W. C., "Selected Crop and Livestock Budget Piedmont Area of Georgia," Georgia Agricultural Experiment Stations, Mimeo Series N. S. 127, (September 1961).

17. Wise, J. O., "Selected Crop and Livestock Budgets for North Georgia," Georgia Agricultural Experiment Stations, Mimeo Series N. S. 191, (March 1964).

18. McArthur, W. C., Saunders, F. B., and Steanson, O., "Budgets for Selected Crop and Livestock Enterprises (Economic Areas 7A and 7B, Coastal Plain Area of Georgia," Georgia Agricultural Experiment Stations, Mimeo Series N. S. 133, (January 1962).

19. Hubbard, J. W., Burch, T. A., and Butler, C. P., "Estimated Production Requirements and Returns from Selected Crop and Livestock Enterprises in the Upper Coastal Plain Area," South Carolina Agricultural Experiment Station, AE 243, (1963).

20. Clark, G. W., and Partenheimer, E. J., "Costs and Returns from Crop Production in the Wiregrass Area Lower Coastal Plains, Alabama," Alabama Agricultural Experiment Station, (August 1961).

21. American Society of Agricultural Engineers, "Farm Machinery Costs and Use," 1967 Agricultural Engineers Handbook, pp. 252-257, (May 1967).

22. Clark, T. F., and Wolff, I. A., TAPPI, 48(6): 381-384, (June 1965).

23. U.S. Forest Service, Technical Note No. 191, Forest Products Laboratory, Madison, Wisconsin, (1953).

24. U.S. Forest Service, "Feasibility of Using Lake States Hardwoods for News Print and Other Paper Products," (1959).

25. Clark, T. F., et al, TAPPI, 48(10):780-786, (October 1962).

26. William, R. L., and Hunt, V. G., "An Economic Evaluation of Forestry Alternatives in the Yellow Creek Watershed of Mississippi," AEC. MR. No. 41, Mississippi Agricultural Experiment Station, (June 1964).

27. U.S. Forest Service, Research Note SE-81, (August 1967).

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KENAF CULTURAL PRACTICES - PANEL PRESENTATIONS

J. H. Williams, Moderator

SEED TREATMENT AND PLANTING EQUIPMENT

By E. L. Whiteley

Seed of the kenaf variety 'Everglades 71' were treated with four compounds - Captan, Ceresan, Delsan, and Semesan. The results from greenhouse and field trials indicate that any of these materials may be used as a fungicide on kenaf seed (Tables I and II).

Table I. Number of Seed Germinating after Treatment and Seeded in Greenhouse Flats

Material	Number planted	Number of seed germinating		
		Rep. I	II	Mean
Captan	50	45	45	45.0
Ceresan	50	44	45	44.5
Delsan	50	42	47	44.5
Semesan	50	29	30	29.5
Check	50	47	44	45.5

Table II. Number of Seed Germinating after Treatment and Seeded in the Field

Material	Number planted	Number of seed germinating				
		Rep. I	II	III	IV	Mean
Captan	48	37	30	26	33	31.5
Ceresan	48	35	43	27	45	37.5
Delsan	48	45	29	35	35	38.0
Semesan	48	41	38	30	32	35.3
Check	48	31	32	31	38	33.0

Planting equipment for kenaf culture varies with the area and climatic conditions of the area. The fertility levels of the soil and availability of irrigation water determine row spacings and plant densities. With adequate chemical weed control any method of seed distribution can be used for planting of kenaf seed. We have used a grain drill in experimental plantings and varied the row width from 7 to 42 in. Any type of planter such as those used for planting grain sorghum or corn with the proper plates can be used to plant kenaf. However, the new types such as the flexi-planters do a much better job of planting than the older types of planters.

KENAF FERTILITY

By D. G. Cummins

Fertility research on kenaf has been limited and results are not conclusive. Most of the reported work has been concerned with nitrogen.

Reports on nitrogen experiments in Nebraska, Kansas, Indiana, and Georgia show nitrogen response only in Kansas. Past history of the soil areas used are probably partly responsible for this lack of response to nitrogen.

A test has been conducted at Experiment, Georgia, on the same plot area for 2 years. In the first year, no response was obtained from lime, nitrogen, phosphorus, or potassium. The second year (1967), treatment differences are becoming apparent, especially the nitrogen variables. Plans are to continue this test on the same area until soil levels of the various nutrients are such to better define the fertility requirements of kenaf.

Reference

1. Williams, J. H. Agron. J., 58(2): 166. 1966.

WEED CONTROL METHODS FOR KENAF IN NEBRASKA

By J. H. Williams* and O. C. Burnside

In 1964, a preliminary study showed that trifluralin was the most selective herbicide for kenaf. In 1965 and 1966 kenaf ('Everglades 71') was seeded in 20-in. rows with stands of 1 plant per 2 in. Trifluralin was applied preplant and immediately incorporated into the top 2 in. of soil. Weed control treatments were weedy check, hand weeded weekly, and trifluralin at 1 and 2 lb per acre. Main plots were 0 or 2 cultivations where weedy plots required cultivation.

Cultivated plots had significantly less weed yields than noncultivated plots. Trifluralin at 1 lb was as effective as 2 lb per acre and cultivation plus trifluralin significantly increased weed control. Weeds that were present included smooth pigweed, green foxtail, and crabgrass.

Kenaf stem dry-matter yields were increased by cultivation only in the weedy check plots. Plots receiving 1 lb and 2 lb trifluralin produced similar yields which were equivalent to hand-weeded plots. Stem diameter was greatest in the 2-lb rate.

* Presented by J. H. Williams

ROW-WIDTH AND PLANT-DENSITY STUDIES WITH KENAF IN NORTH CAROLINA

By W. T. Fike

Kenaf has been grown in North Carolina since 1959. Most of the emphasis has been placed on row-width and plant-density studies but varieties, planting dates, and fertility have also been evaluated.

Intrarow spacings of 2, 3, 4, 5, 6, 8, 10, and 12 plants per row ft. in 7, 14, 21, 28, and 35 in. rows have been compared. The following conclusions have resulted from these studies:

1. Highest dry-matter yields were obtained in 14-in. rows.

2. The lowest dry-matter yields were obtained in the narrower 7-in. rows and the wider 28- and 35-in. rows.

3. Highest dry-matter yields were obtained at the lowest seeding rate in the 14-in. rows and at the highest seeding rates in the 21- and 28-in. rows. The stand in the 7-in. rows was usually the same no matter what the seeding rate.

4. Plant heights and stem diameters were greater at the lower densities within each row width and increased as row width increased.

5. Yields from May 1 plantings were 25% greater than yields from June 1 plantings.

SOME CULTURAL ASPECTS OF KENAF (HIBISCUS CANNABINUS L.) WHEN GROWN IN NORTH CENTRAL FLORIDA

By G. B. Killinger

Kenaf has been grown in Florida for a number of years mainly as a fiber plant for yarn and cloth fabrication. All of the early research on this crop was in south Florida in the Everglades area and more specifically at the Everglades Experiment Station at Belle Glade on both organic and mineral soils. An active kenaf breeding program conducted during the 1950s and early 60s resulted in the release of two varieties, Everglades 41 and Everglades 71, both high-yielding, late-maturing types.

Since 1958 a rather limited research program on the culture of kenaf in north central Florida on several soil types has been under way at Gainesville. In this area, kenaf was first grown on upland soils especially the hammock type which are rolling or undulating and apt to be nematode infested but considered good for most field crops. Kenaf is susceptible to the gall forming root-knot species, namely *Meloidogyne incognita* and *M. incognita acrita* and these organisms do infect the root systems when grown on these soils causing a decrease in yield and in some instances death of the plants before maturity. By 1962 it was determined that because of the seriousness of root-knot on kenaf, some other more favorable situation would have to be found if this crop was to be grown successfully. Clovers, both white and red, are also susceptible to the root-knot organisms, however, they are grown successfully on the moist to wet flat-woods soils of which this State has some 12 to 15 million acres. It was therefore only natural to try kenaf on these wet soils to determine if the crop would prosper under such conditions which during certain months may actually be flooded or covered with surface water.

In 1962, a trial planting was made on the Beef Research Unit near Gainesville on a Leon fine sand. These trial plots were not bothered by the water and yields of 12 to 15 tons per acre of oven-dry stems were harvested the first season. It was noted that excessive rain at planting or seedling stage caused many of the emerging plants to damp-off or die, much like cotton seedlings. Different systems were tried resulting in the present recommendation of broadcasting 600 to 1000 lb. per acre of 8-8-8 or 10-10-10 fertilizer over the prepared seedbed in early April, bed the rows to be planted to a 10- to 12-in. height in 38-in. rows and drill the kenaf seed on top of the bed. This bedding procedure allows for a water reservoir or drainage between the rows and for the past four seasons has kept the young seedlings from being flooded. In addition, since the fertilizer was broadcast ahead of bedding, most of the fertilizer ends up well distributed

in the bed with very little between rows in the water furrow. For this area the month of April seems best for planting. Moisture must be available for the seed to germinate; however kenaf is quite drought-tolerant and once the seedlings are up they can stand considerable dry weather. Some four to five weeks after planting, experience has shown that the plants will respond to 80 to 120 lb. of supplemental nitrogen. Ammonium nitrate, calcium nitrate and liquid nitrogen fertilizer have all been used sucessfully. Other forms of nitrogen may be just as effective as those listed. In 1967, a severe potash deficiency developed within 10 weeks after planting, as evidenced by foliar symptoms. This was corrected by top-dressing between the rows with 90 lb. per acre of K_2O combined with 100 lb. of nitrogen.

Average yields of kenaf over the past four seasons, excluding 1966, range from 7 to 10 tons of oven-dry stems per acre when harvested in October, November, or December. In 1966 due to local problems the kenaf was seeded in mid-May and several periods of above normal rainfall coupled with cloudy days stunted the seedling plants and they never fully recovered. Yields in 1966 were in the 5 to 6 ton range. Yields of oven-dry kenaf stem have been recorded as high as 20 tons per acre at Gainesville. It seems a yield of 7 to 10 tons could be expected from field plantings with higher yields for certain seasons and on the better soils. Kenaf will grow under acid soil conditions but, for most efficient and effective use of fertilizer material, the soil should probably be limed to a pH of 5.8 to 6.5. Part of the lime should be dolomite to eliminate any chance of a magnesium deficiency. Minor elements copper, zinc, manganese, iron, and boron have been tried with no positive results at this time.

Within two to three weeks following frost, kenaf stems become mottled in appearance with mold and other organisms attacking and much breakage or lodging occurs.

There are about 18,000 kenaf seeds per pound, depending upon variety and seed quality, and a 6 lb. seeding rate per acre in 38-in. rows has proven to be satisfactory. If grown in 19-in. rows, 12 lb. of seed per acre appears desirable; however it is impossible to do much bedding on 19-in. rows. On upland soils kenaf broke over and lodged badly when grown in 19-in. rows with little or none of this problem from 38-in. rows. Perhaps two rows to a bed and beds 30 in. apart or some similar practice would promote higher yields. Machinery to vary the bed spacing has not been available.

At this time, it would appear desirable to use a fungicide such as Captan on the seed before planting to help present seedling diseases.

Some of the research aspects which still need consideration are:

1. The breeding of large diametered, higher-yielding varieties.
2. The breeding of varieties which do not flower or seed under our day length regime.
3. The breeding for root-knot nematode and disease resistance.
4. The determination of optimum seeding rates or spacing of plants.
5. The determination of major and minor nutrient requirements.
6. The development of a better harvesting machine.
7. The determination of preservative methods for year round storage of kenaf.
8. The development of reliable and economical seed sources.
9. The identification and control of insects or disease which may affect kenaf.
10. The further study of kenaf in crop rotations. Two years of kenaf followed by Pensacola bahiagrass and clover to be used for pasture for two years, may be an effective method for control of insects and diseases as well as improving soil fertility.
11. All agencies and companies should cooperate fully on cultural investigations and practices.

References

1. G. B. Killinger, Sunshine State Agr. Research Report. 10(2): 4. 1965.

2. G. B. Killinger, "Proceedings Second International Kenaf Conference" pp. 54-57. 1965.

PREDICTING KENAF STEM YIELDS

By J. J. Higgins

With presumably adequate soil moisture, kenaf stem yields in 1962 of 2.5 and 15 tons (dry-weight basis) per acre were obtained at Rosemount, Minn., and College Station, Texas, respectively.

These variations are related to the different climates of these areas and the length of the growing season. The question arises as to what yields may be expected in other areas and how they might vary from one year to the next in individual localities.

Since it is not convenient to harvest kenaf stems several times each week during the growing season to determine how climate affects stem yields, another approach must be used.

At Glenn Dale, Maryland, we have observed that the production of leaves is a sensitive indicator of climatic control of kenaf growth. During the period of 1961 to 1967 new leaves were produced at an average rate of 0.2 of a leaf per day in early May and mid-October to somewhat more than 0.6 in midsummer. On very hot days, only 1 day was required to develop one new leaf, while on days when temperatures were just above 50 F, 20 days were required to develop a new leaf.

A comparison of the average daily leaf development with average temperature on a day-by-day basis shows that in the spring kenaf leaves begin to develop at approximately 50 F. In late summer and fall leaves appear to develop somewhat faster than in the spring for any given temperature.

From a direct comparison of daily leaf development plotted against average temperatures, we estimated the leaf development that may be expected at temperatures higher than those observed at Glenn Dale.

The relationship of stem yield to leaf production was determined for stalks harvested at different stages of total leaf development. We found that 5, 10, 15, and 20 tons of kenaf stems were related to 59, 102, 147, and 192 total leaves. We have observed only 87 leaves during a year of maximum production at Glenn Dale.

We predicted yields for several areas of the United States on the basis of average monthly temperatures by estimating the number of leaves that would develop during the growing season. Stem yields for each area were then calculated from the relationship of leaf development to stem yields. Under conditions of sufficient soil moisture and average expected temperatures,

kenaf yields (tons/acre) can be expected as follows: Brownsville, Texas, 20.6; El Centro, California, 18.5; College Station, Texas, 15.8; Tempe, Arizona, 15.8; Gainesville, Florida, 15.7; Mobile, Alabama, 14.8; Charleston, South Carolina, 13.4; Bakersfield, California, 12.5; Memphis, Tennessee, 10.8; Raleigh, North Carolina, 9.7; Glenn Dale, Maryland, 6.5; Ames, Iowa, 5.5; Morgantown, West Virginia, 5.4; Lafayette, Indiana, 4.5; Hartford, Connecticut, 4.5; Rosemount, Minnesota, 3.8; Cheyenne, Wyoming, 1.6; and Bozeman, Montana, 0.8. Estimated accumulative yields for some of these locations are shown in Fig. 1.

References

1. Higgins, J. J., Haun, J. R., and Koch, E. J., Agron. J. 56(5): 489. 1964.

2. White, G. A. and Higgins, J. J., "Proceedings Second International Kenaf Conference" pp 27-40. 1965.

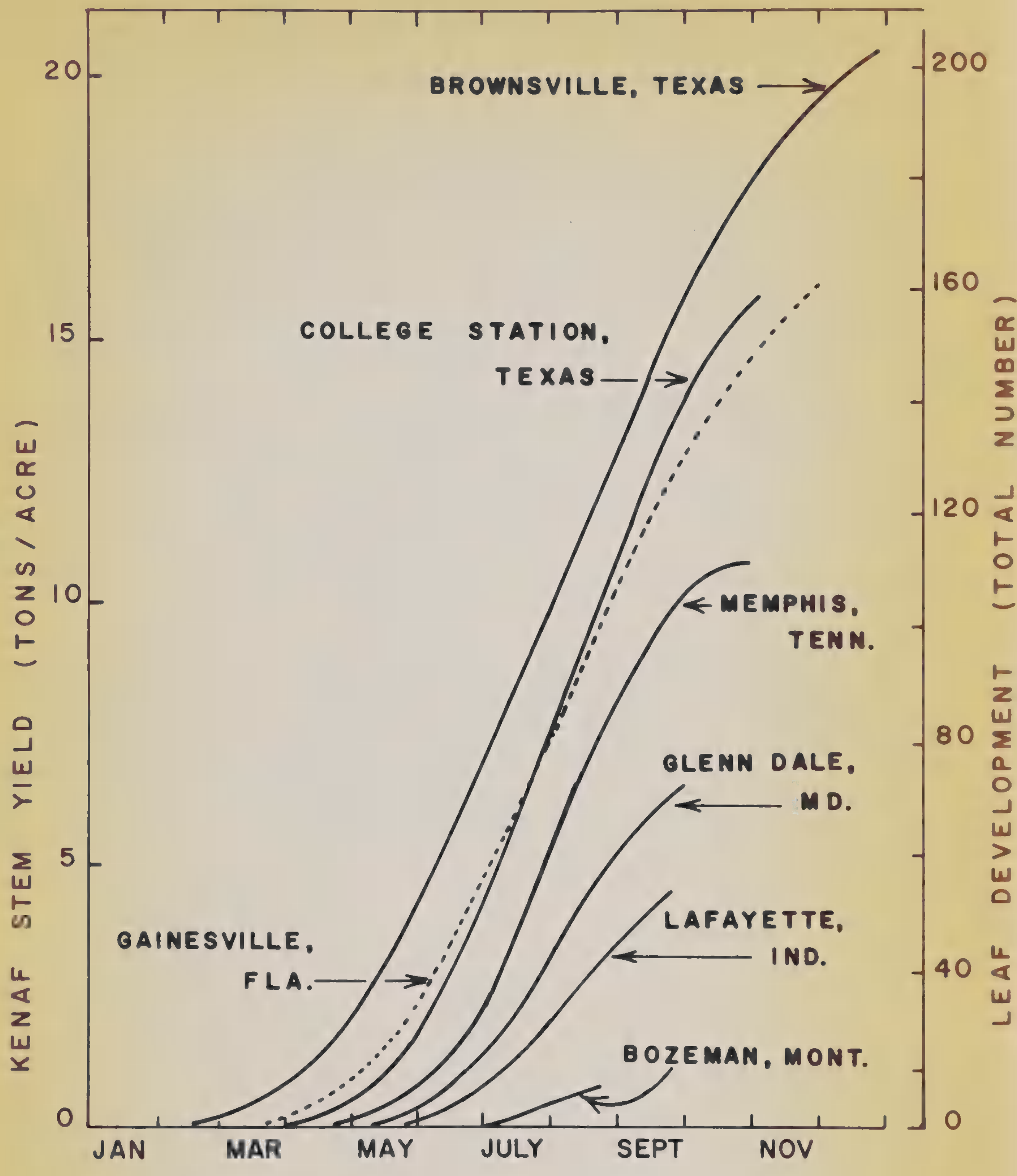

Fig. 1. Estimated seasonal accumulated kenaf stem yield and leaf development at selected locations.

REVIEW OF RECENT AGRONOMIC RESULTS

By George A. White* and J. J. Higgins

There were about 200 acres of kenaf in 1966 and 180 to 200 acres in 1967. Most of the acreage was planted either by or under the auspices of pulp company personnel. Yields from a planting near Columbia, Miss., were limited by severe nematode infestation and excessive moisture. An increase in yield probably could have been obtained by earlier planting. 'Everglades 71' outyielded (8431 lb/acre) 'Everglades 41' (6312 lb/acre). Excellent results from a 5-acre planting (for processing studies) at St. Gabriel, La., are expected. Under more optimum cultural conditions, the yield of this planting could have been substantially increased.

Cooperative varietal trials were set up at Glenn Dale, Md., Clemson, S.C., and Gainesville, Fla. At Glenn Dale, the best yielding varieties were 'Everglades 71', 'G-45', 'Everglades 41', and 'G-4'. Because of poor stands 'Cubano' could not be properly assessed, but its performance was good enough to merit further testing when better seed is available. There was considerable difference in apparent susceptibility to disease (chiefly gray mold which is caused by *Botrytis cinerea* Pers. ex Fr.). The two Everglades varieties were given the best rating. Small plants appeared to be more susceptible to the disease than large plants.

In a 1966 population - date-of-harvest experiment at Glenn Dale, a natural thinning or mortality for all populations occurred. However, the rate was much greater at the higher population levels. A population of about 80,000 plants per acre resulted in the best dry-matter yield. Yields were at the highest level for all populations from an October 4 pre-frost harvest. Subsequent yield reductions were more severe at the higher population levels. In thick stands, plants were smaller in diameter and lodged more than plants in thin stands. This study is being continued in 1967.

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* Presented by George A. White.

KENAF SEED VARIETIES

By Joseph F. Dryer, Jr.

It is as a Director of the North Atlantic Kenaf Corporation that I have the pleasure of addressing you today. I have brought with me the Manager of our Haitian company, Mr. Anilus Barthelemey. He is also a director of the United Nations Experiment Station in Gonaieves, Haiti, and last year he spent four months in West Africa when our company was selected to make a detailed study of kenaf fiber possibilities for the State Department's Agency for International Development.

As you know, the problem of selecting seeds is not only difficult work, but also very complex. Formerly, it was enough to have a keen eye, a sufficient knowledge of botany, knowledge of basic stocks, and with these elements, it was possible to handle selection problems. Today the selector must be surrounded by a group of specialists, geneticisits, physiologists, and phytopathologists. He must also be prepared to work with engineers who deal with the problems of mechanization.

I will not bring up the different systems of selection. I do, however, want to comment that three of the most important problems concerning kenaf are the disease anthracnose, nematodes, and photoperiodism. In the past, the commercial grower of kenaf has been interested primarily in resistance to anthracnose, yield of dry fiber per acre, and the development of seed that can be planted on a year-round basis. He has also been interested in finding varieties of seed that could eventually lead to producing higher count yarns for the carpet industry, and sacks with better burst and abrasion resistance for agriculture.

As a result of the efforts of the U.S.D.A. and U.S. Operations Missions to Cuba and Guatemala, the following commercially available disease resistant varieties were developed:

Early to medium maturity	Late maturing
Cuba 108	Cuba 2032
Cubano	G - 4
Everglades 71	G - 45
Everglades 41	

The best combination of seed for large scale continuous planting and harvesting (on a five-month basis) in Central America has been found to be plantings of Cuba 108 April through June 15, and either Cuba 2032, G-4, or

G-45 from June 15 through September 1. The early to medium varieties usually commence to flower in September. They almost cease growth by October 15. On the other hand, Cuba 2032 and especially G-4 and G-45 continue to grow while flowering and will increase in height at profitable rates as long as water is available and cold weather does not set in.

Our company, North Atlantic Kenaf, is commercially multiplying each of the above listed varieties with the exception of Cubano. We are also experimenting with selections from the Sudan, Republic of South Africa, and one Russian variety which we received via France, but unfortunately lost. Trials will commence again next year. The variety has been found to be successful in large-scale plantings in the Black Sea area.

We cannot over emphasize how pleased we are to have the opportunity to meet with you, as we are certain that the requirements of seed for the paper industry and the rotation crops that will have to be developed will result in selections that are quite different from the seed currently in use.

The development of seed for the various markets that appear to be developing in the pulp and paper industry, as well as the intriguing possibility of utilizing the waste tips in the cattle and chicken feed industry, is a long-range task that should commence immediately. It will require close coordination between paper companies, agricultural research agencies as provided by the U.S.D.A. and universities, and commercial multipliers of seed, such as ourselves. We unfortunately do not have the facilities to do the very lengthy and quite costly work of selections, and therefore must cooperate closely with those that do. On the other hand, our sixteen years of experience growing our own commercial crops, as well as test planting for other companies in Florida, Cuba, Haiti, Guatemala, Salvador, Costa Rica, Columbia, Equador, Peru, West Africa, and now in Panama, has given us a large fund of experience and agricultural and economic data.

Most of our operations are outside of the United States. Currently, we are multiplying seed in Haiti and Central America. You may wonder why we go so far, rather than plant in the more politically and economically stable area of the southern United States. The reasons are several.

We have grown seed in Florida not only for export, but for the Commodity Credit Corporation in the early 1950's, and for our own past needs in Cuba. We found that not only were our costs almost 50% higher, but that yields per acre, after mechanically harvesting and drying, were invariably 30% lower. Other important factors are that flowering takes place between October and December, depending upon the variety. The seed then is normally threshed

between December and January. Almost all of the United States is subject to frosts that can easily damage or kill the crop. Hurricanes are also something of a danger, but can be guarded against in Latin America by planting in protected areas. Furthermore, roguing, hand care, and partial hand harvesting are much more effective and considerably less costly outside of the United States. I could continue at some length to name other advantages, but time does not permit. Let it suffice to say that our trained Spanish and French speaking personnel located in Haiti and Central America can do as fine a job of producing clean, high germination, and morning glory free seed as any company that I know.

Our men have consistently found that kenaf has an amazing ability to withstand adverse conditions in different latitudes, rain belt areas ranging from thirty inches a year to one hundred and sixty inches in Equador, and soils ranging from sandy to heavy clay. Like any crop, it responds beautifully to proper treatment, but it is not so delicate that a dry period of several weeks, or a prolonged week or two of rain (providing the soil has good drainage) will kill the plant.

COMPOSITION OF KENAF JUICE

By I. A. Wolff,* M. O. Bagby, and M. C. Cadmus

Satisfactory procedures must be evolved for storing kenaf between time of harvest and its utilization as raw material in a pulp mill. One possible procedure for green plant material is analogous to that for sugarcane in which juice is first expressed, and the residual bagasse then baled or otherwise compacted for handling. Of immediate concern is the value of the juice. Will it be a useful by-product for which a market can be found or a troublesome waste to dispose of in a manner to avoid pollution? Studies at the Northern Laboratory have been directed toward determination of the chemical composition of the kenaf juice and, based on that composition, toward exploring selected prospective uses.

Juice from both autoclaved and raw green kenaf plants was recovered by use of a laboratory press. The juice contained about 6% solids; this dry matter in the juice represented about 2% of the green plant weight. The juice solids comprised about 1/4 ash, 1/10 to 1/5 apparent crude protein (determined as Kjeldahl nitrogen X 6.25), and about 1/5 total sugars, a remainder of about 35-40% being as yet unidentified. Nitrogenous constituents were largely nonproteinaceous; free amino acids or low-molecular-weight peptides were present. Most of the sugar was reducing sugar. Only trace amounts of lipids or essential oils were found.

Laboratory studies suggest that kenaf juice is a good substrate for fermentative production of the commercial polysaccharide gum B-1459 by use of the bacterium Xanthomonas campestris. The juice has also been used in the laboratory successfully to grow Arthrobacter viscosus and other polysaccharide-producing microorganisms. The juice or juice solids should provide a satisfactory feed additive, but no feeding trials have yet been made.

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* Presented by I. A. Wolff

POTENTIAL VALUE OF KENAF TOPS AS A LIVESTOCK FEEDSTUFF

By Glenn M. Cahilly

Preliminary analysis of several varieties of kenaf indicate a relatively consistent proximate nutrient composition. The average figures for the leaves are: crude protein, 27.12%; ether extract, 7.3%; fiber, 8.39%; ash, 5.71% as determined at a moisture content averaging 9.48%. Amino acid analysis of the leaf proteins shows a pattern similar to that of alfalfa. Further data are presently being collected on vitamin content and also on the biological value of the various nutrient components of a pelleted form of kenaf tops as determined by ruminant balance feeding trials.

KENAF AS SILAGE

By G. W. Powell and J. M. Wing

Kenaf was planted in rows at the rate of 3 to 5 lb. of seed per acre on April 19, 1966. At planting, 400 lb. of 5-10-15 was broadcast and 60 lb. of nitrogen was applied when the plants were 6 in. tall. The crop was cultivated twice with a rotary hoe. The whole plant was cut for silage, chopped into lengths of about one in., on July 27. The plant was in a very leafy state and the yield was approximately 6 tons per acre which equaled 1,968 lb. of dry matter. One small silo was filled with kenaf alone, and another was filled with kenaf plus 150 lb. of ground shelled corn per ton of forage. Both silages were fed as the only feed to dairy heifers weighing approximately 1,000 lb. each.

Silage recovery data showed that the ensilability of kenaf compared favorably with that of other popular silage crops and that it ensiled very efficiently with or without ground shelled corn being added as a preservative. Percent recoveries of control and treated silage constituents, respectively, were: dry matter, 85 and 90; energy, 85 and 88; protein, 80 and 87. The silages were readily consumed by dairy heifers. Daily consumption rates 1,000 lb. body weight were 149 and 117 lb. of silage, 24.4 and 24.9 lb. of dry matter, 14.4 and 15.6 lb. of digestible dry matter, 29 and 31 megacalories of digestible energy, and 2.3 and 2.0 lb. of digestible protein. The digestibility of the silages compared favorably with the digestibility of many forages. Percent digestibility of constituents were as follows: dry matter, 58 and 64; energy, 61 and 65; protein, 59 and 56.

Another experiment is in progress at the present time to compare the ensilability and feeding value of two growth stages of kenaf, with and without propyl paraben added as a preservative. The first stage was harvested 62 days following planting and the second stage at 83 days. The heights of the plants averaged 6 and 8 feet, respectively. Proximate analysis revealed that the first stage harvested contained 11.6% dry matter, and the following on a dry-matter basis expressed as percent: protein, 24.3; fat, 3.1; fiber, 28.5; ash, 11.0; and NFE, 33.1. In this trial kenaf did not recover sufficiently to achieve a second cutting.

Reference

1. Wing, J. M. Feedstuffs 39(29): 26. 1967.

SYSTEMS OF HARVESTING AND HANDLING KENAF

By L. H. Wilkes and Eli L. Whiteley*

In the development of any crop the agronomic, harvesting, handling, transportation, marketing, and processing problems should be studied and solutions developed to these problems concurrently. Due to many factors, the harvesting and handling of kenaf have received less study than the other problems. A small amount of research has been carried out on kenaf harvesting and handling. Most of the work that I will report to you was carried out by personnel of the Texas Agricultural Experiment Station. Part of the material presented is based on experiences encountered in the past 8 years research on kenaf. Several types machines have been evaluated and they will be discussed briefly. Bulk density values for kenaf harvested with the various units are presented in Table I.

Table I. Bulk Densities of Kenaf Harvested with Different Machines

Machine	Condition In Truck	Density, Pounds per cu. ft. (Oven Dry)
Forage Harvester	Loose-3/4" cut	4.73
Forage Harvester	Loose-3" cut	4.41
Row Binder	Bundles-Whole	2.76
Flail Chopper	Loose-1" cut	3.11
Baler	14" x 18" x 28.5" bales	8.34
Experimental Saw	Loose-12" cut	2.41

Forage Harvester

Two types were used in this work. (1). A self-propelled unit and (2). A pull-type unit which was driven by the power take-off of a tractor.

The self-propelled machine was a Gehl SP 188 which was manufactured by Gehl Brothers Manufacturing Company, West Bend, Wisconsin. The machine was

* Presented by Dr. Whitely.

equipped with a 123 horsepower gasoline engine. Up to eight knives can be mounted on the blower disk or fly wheel. The length of cut can be varied by the number of knives used on the fly wheel along with a transmission gear box which regulates the feeding rate into the fly wheel or cutting mechanism. In this research the two settings reported were: (1) eight knives with the long feed rate and (2) two knives with the long feeding rate. This gave cuts of 3/4 inch and three inches respectively for the settings indicated above.

Two harvesting headers were used with the SP 188 forage harvester. These included a two-row crop attachment and a sickle bar or broadcast attachment. The row-crop attachment worked well during the test except for the height of cut above ground level. The broadcast attachment did not work well where the height of the material was more than 10 feet.

The pull-type harvester used in this material was an International Harvester Model 55 forage harvester. This machine was equipped with row-crop and broadcast header attachments. Its power was supplied by the power take-off of a tractor. The length of cut could be changed by changing the number of knives on the reel-type cutting mechanism and a three speed gear box. The range in length of cut was from 5/8 inch to 1 1/2 inches.

Flail Chopper

A flail-type rotary chopper which employed a horizonal shaft with 40 vertical, free-swinging, rotating knives was used in the research on kenaf harvesting. This pull-type harvester was driven by a tractor power take-off and was equipped with a wagon discharge spout. From 10 to 20 percent of the material was lost during harvest with this machine.

Cutter Crimper

An International Harvester Model 816 mower-conditioner was used to test the possibilities of using hay harvesting equipment for the harvest of kenaf. This machine had a 9-foot sickle bar and was driven by a tractor power take-off. The machine was equipped with a windrowing attachment. This machine worked well in the material where the stem diameters were 1/2 inch or less. A good job of crimping of the stalks could not be obtained on larger stem diameters due to the variation in the stem diameter from bottom to top.

Baler

The baler used in this study was an International Harvester No. 47 Automatic Baler. The size of the bale chamber was 14 by 18 inches. The length

of bale was adjustable and a length of 28.5 inches was used in this study. The baler worked satisfactorily in kenaf that had been crushed by the cutter-crimper. In the material that had not been crushed the baler would not pick up the material and feed it into the baler.

Binder

The binder used in this study was manufactured in Denmark. It was mounted on the front of a tractor and driven by the tractor power take-off. The sickle bar was four feet wide and the plants were cut and held vertically through the cutting, accumulating and tying mechanism. The machine operated best on a single 40 inch row. It operated well where the plant height was six feet or less and the stem diameter was 1/2 inch or less.

Experimental Harvester

An experimental harvester was built by the Agricultural Engineering Department and evaluated in the laboratory. This harvester used 11 saws to cut the kenaf stalks in 12 inch lengths. This machine worked well in the laboratory and power requirements were reduced with this machine.

Elevator

An International Harvester No. 24A farm-type elevator was used to convey materials harvested in the various systems. This machine was a drag-type and had a maximum discharge height of 28 feet. All materials could be conveyed satisfactorily. A small amount of bridging over occured with the material harvested with the forage harvesters.

Effective Machine Capacities When Operating Under Normal Field Conditions

The maximum capacities of each machine were determined while the machine was actually harvesting. Performance data for machines operating at maximum field capacities are shown in Table II. Under field conditions the capacity of the machine will be reduced because of time loss which occurs while turning on the ends of the rows. Time and motion studies indicate that about 15 percent of the total time was lost during the turns at the ends of the rows. Therefore, only 85 percent of the time in the field is actually utilized in the harvesting operations. The self-propelled forage harvester had a wrapping problem which reduced the harvest time to 55 percent. The bast fiber wrapped around the fly wheel shaft and the machine had to be stopped and the fibers removed after each load was harvested. The relationship between yield and speed of the SP 188 machine is shown in Fig. 1.

Cost of Harvesting Kenaf

The total estimated cost per ton of oven dry material includes the probable life, repair cost, depreciation, remaining value, interest on investment at 6 percent, and labor. These costs include all costs required to place the harvested kenaf at the end of the rows or on the "turn row". Labor was calculated at $1.50 per hour. The calculations are summarized in Table III.

Table II. Performance Data for Harvesting Machines at Maximum Field Capacities (No Time Loss)

Machine	Average Speed, M.P.H.	Swath, No. Rows	Average Capacity, Tons/hr.	Peak Capacity, Tons/hr.	Average Capacity, Acres/hr.	Average Yield, Tons/acre
Forage Harvester S.P. 3/4" cut	3.85	2	12.90	14.50	3.10	4.17
Forage Harvester S.P. 3" cut	5.30	2	14.98	20.70	4.26	3.52
Forage Harvester Pull type	3.05	2	9.00	11.50	2.47	3.65
Flail Chopper	2.27	2	4.88	6.18	1.84	2.65
Cutter-Crimper	4.00	2	7.26	9.10	3.23	2.24
Baler	3.98	2	7.20	8.10	3.20	2.25
Binder	2.69	1	2.90	3.12	.89	3.26
Experimental Saw	5.50*	1	9.00	10.80	2.22*	4.05*

* Calculated performance based upon laboratory capacity determinations.

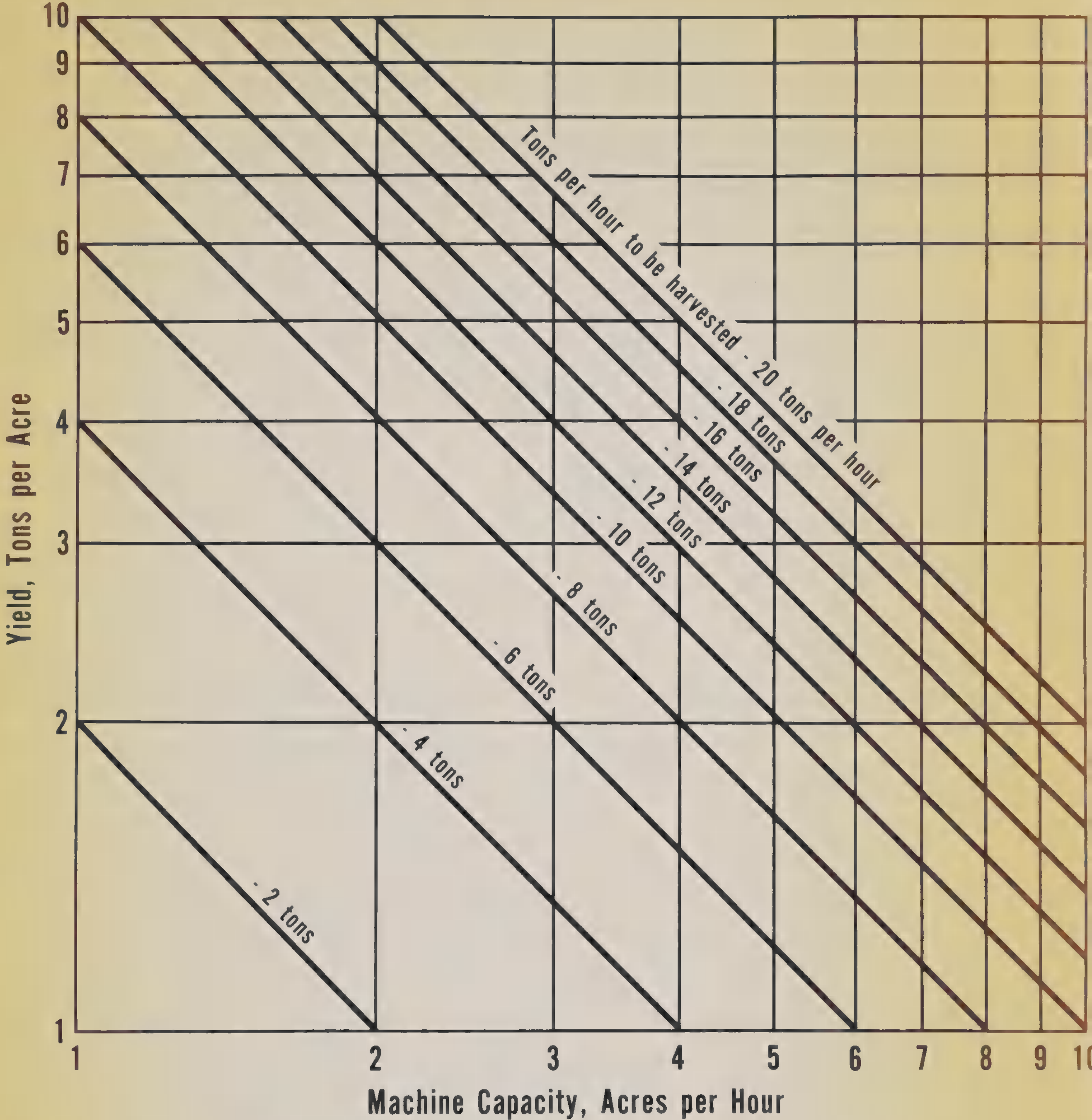

Fig. 1. Relation between yield and speed of machine.

Table III. Total Estimated Cost of Harvesting and Hauling Kenaf to the Turn Row Including Machine, Truck and Labor

System of Harvest	Field Efficiency, %	Cost Per Ton, $			
		Machine Cost	Haul	Labor	Total
Forage Harvester-S.P. 3.4"	85	1.06	.24	.27	1.57
	55*	1.64	.37	.42	2.43
Forage Harvester S.P. 3"	85	.91	.20	.24	1.35
	55*	1.41	.31	.36	2.08
Forage Harvester-Pull Type	85	.82	.34	.39	1.55
Flail Chopper	85	1.16	.62	.72	2.50
Baler	80	1.51	.52	1.68	3.71
Binder	85	2.77	1.15	3.83	7.75
Experimental Saw	85	.73	.34	.39	1.46

* Actual amount of time that the machine could be operated.

HARVESTING, HANDLING, AND STORAGE OF KENAF - PANEL PRESENTATIONS

E. L. Whiteley, Moderator

KENAF HARVESTING

By S. C. Uhr

Our experience at Hudson Pulp and Paper Corp. in the harvesting of kenaf has been limited to conventional forage harvesters with corn head pickup (field choppers) harvesting kenaf grown in 38 to 40 in. rows. My remarks will be limited to this method of harvesting. First let me state the case as we see it for this method of harvesting kenaf. We feel that for efficient loading and rapid cooking in the digester, a finely chopped form has many advantages. This form is also quite amenable to bulk handling and storage methods. Further, existing equipment is available for this method of harvesting thus allowing us to greatly reduce development cost and time as compared to almost any other harvesting method.

Our experience in using forage harvesters has ranged from hand feeding several hundred pounds of kenaf through a machine to obtain chopped material for a sample digester cook to the harvesting of 10 acres of kenaf for an experimental mill run (discussed by Gary Guttry, Nov. 1. 1967). Our experience has ranged over a period of 4 years with some harvesting being accomplished in each of these years. This year we have completed the harvesting of 10 acres of kenaf, approximately half of which went into a pilot-scale storage test using a bunker-type silo for anaerobic storage.

From our experience the following desirable features of a forage harvester for kenaf have become evident:

1. The machine must be of a very rugged design - this means using the "top of the line" machine and expecting a lower production rate when compared to chopping corn due to the harder and tougher nature of the kenaf stalks.

2. Extremely close tolerances must be maintained between cutter knives and the bed-knife in order to obtain a clean cut. This cannot be over emphasized. Failure to cut cleanly will result in undue fraying and crushing of fibers. Too wide a spacing here can result in "ribboning" of the bast fiber portion of the stalk instead of cutting. Ten to 25 thousandths of an inch seems to be the allowable limits for satisfactory operation. From our experience it appears that only cylinder-type machines can be consistently held to these close tolerances with the fly wheel machine, due to less stable mounting

and some inherent "wobble," requiring greater tolerances in order to prevent contact between cutter knives and the bed-knife. Failure to cut cleanly can result in severe wrapping of bast fibers around the shaft of a fly wheel-type machine. Fortunately, it seems that most manufacturers are replacing fly wheel machines with cylinder machines as new models come out. The new John Deere Model 38 machine (demonstrated on Nov. 1, 1967) represents one manufacturer's changeover from a flywheel to a cylinder machine.

3. In order to efficiently feed the cutter head with the relatively stiff stalks of kenaf it appears that an apron-type of feed mechanism is superior to toothed or corrugated rolls. The greater purchase of an apron on the stalks results in less clogging at the cutter head from our experience. Again, the newer machines of most manufacturers are incorporating this feature.

4. The extreme height (up to 20 ft.) of kenaf has created serious problems in all of our attempts at harvesting. Some lodging of stalks, even when employing a high push bar, has been experienced with subsequent clogging of the cutter-head throat. To alleviate this situation it is recommended that some mechanical topping device be employed to sever the top 24 to 30 in. of stalks immediately ahead of the forage harvester. Besides eliminating the problem of lodging, removal of the leafy top portion of stem will allow the return of this highly nitrogenous material to the soil. We anticipate using a topping device in next year's harvest. Apparently some of the newer machines are designed to accommodate material as tall as 18 ft., but I have personally not observed machines harvesting material of this height in a completely satisfactory manner.

While we have not been completely satisfied with the performance of machines tested in our operations, results have been such that we are convinced that with minor modifications some existing forage harvesters can be utilized for harvesting kenaf on a production basis, thus alleviating the cost and time required for development of a completely new harvesting system.

KENAF STORAGE

By D. G. Cummins

The length of time kenaf can be stored without being deterimental to pulp quality is important to processors who want to maintain a backlog of material.

Mature kenaf was baled, stored under three conditions: inside a building, covered stack outside, and an open stack outside for an 18-month period at Experiment, Ga. Samples were taken at 0, 6, 12, and 18 months for compositional and pulping evaluation by the Utilization Laboratory at Peoria, Ill. Only the compositional study is complete at this time.

Tentative observations pending completion of the work are as follows: For material stored inside or in a covered stack, an apparent loss of cellulose with time was shown. This may be attributable to the initial moisture content of the bales (about 20%). Lignin and ash content show similar trends. Change in pentosan content is minor. Solubility in 1% alkali increases with duration. This may also be the result of the extra moisture content at baling time. For material stored in the uncovered stack, there was a loss of material soluble in 1% sodium hydroxide. For cellulose, lignin, and pentosans, there were apparent increases. These changes might be accounted for on the basis of leaching of solubles by rain water.

MECHANICAL DEWATERING OF FORAGE CROPS[1]

By T. W. Casselman

Mechanical dewatering, as used in this text, will indicate a process in which some of the moisture in forage materials is removed mechanically as a first step in the processing of a livestock feed. The objective of mechanical dewatering of forage crops is to reduce the moisture content, without excessive loss of nutrients, to a level that will allow economic thermal dehydration.

All forages when converted into dry feeds with acceptable storage characteristics must have excess water removed, preferably without appreciable loss of the desirable nutrients found in the original crop. The time-honored method of field curing hay, utilizing the sun's energy to remove excess moisture, appears on the surface to be an economical system. Unfortunately, this system has certain inherent disadvantages, i.e., leaching and shattering losses due to exposure to the weather and mechanical handling. In some areas such as South Florida, this system is impractical due to high humidity, high soil moisture, and frequent showers. Under these climatic conditions vegetative growth is rapid and lush, and green weight yields are high but these same conditions are responsible for the problems encountered in processing high moisture forage. Large quantities of water must be removed from the plant, and the commonly used methods are either not adequate or economical. Mechanical dewatering was studied as a means of removing some of the initial moisture in a forage prior to further processing and the results of these studies are reported herein.

REVIEW OF LITERATURE

Since 1942, British researchers have studied the principles of mechanical dewatering to extract protein from plant materials for human consumption. Pilot plant production of plant protein for human consumption has been studied since 1948 (3). In 1963 installation of a bulk protein extraction unit at Kingston, Jamaica was completed, indicating that mechanical removal of juice and nutrients is feasible[2].

The general procedure has been to pulp the fresh leaves or plants into a semiliquid, fibrous mass, before removing the juice in a mechanical press. Pirie (1) described several types of mechanical presses which can remove 50 to 90 percent of the fluid from a pulp initially containing 80 to 90 percent

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[1] Everglades Station Mimeo Report EES68-4.

[2] Personal communication from N. W. Pirie dated February 27, 1963.

water. He also reported that 50 to 60 percent of the protein in the initial crop can be collected in the expressed juice by this method (2). The protein-containing solids can be separated from the juice by heat coagulation or acid precipitation. The remaining fibrous materials from which much of the nutrients and moisture have been removed is generally discarded, but could be used as roughage for ruminants.

To remove the greatest amount of the protein in the juice, Pirie (1) recommended that the layer of material after pressing should not exceed one inch in thickness. As the compressed mat increased in thickness, more of the protein in the solid mass of forage was retained by the filtering action of the compressed fibers. The expressed juice emerging thus contained less nutrients. The goal in adapting these principles to the mechanical dewatering of forage crops should be protein retention in the fibrous portion of the plant.

Italian researchers (4) utilized these principles in the PAST (Prodotti Alimentari Sistema Tallarico) system to obtain up to one-third more hay as compared with normal hay making procedures and by avoiding leaf shattering and leaching losses associated with normal hay making. They reported hay thus made to be higher in nutritive value than sun cured hay.

Experimental mechanical dewatering of forage crops and potential forage crops grown in the Florida Everglades was begun in 1955 at the Everglades Experiment Station. The major objectives of these studies were to determine: 1) the feasibility of dewatering local forage crops using available equipment, 2) the amount of water which can be removed from crops by mechanical dewatering over a range of initial moisture contents, 3) the effect of pressing on the nutritive content of various crops, and 4) ways to utilize the pressed forage effectively.

EXPERIMENTAL DEWATERING EQUIPMENT

Dewatering was accomplished with several screw-type presses of different sizes[3/]. These presses are commercially available and are currently employed in many industrial operations. They contain broken flight augers turning at a low speed within a cylindrical screen. Each auger section has a pitch less than the preceding section.

In theory the press operates as follows: as the forage moves through the press by auger sections of progressively decreasing pitch, the volume moved per revolution of the screw decreases. Compaction results to generate the pressures necessary to expel the juice. To aid in keeping the cylinder full and the pressure constant, a compressed air controlled choke cone at the outlet

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[3/] Presses used in these studies were manufactured by Dan B. Vincent, Inc., Tampa, Florida.

of the press is forced against the outcoming forage by an adjustable pressure air cylinder. Stop bars attached to the frame of the press and extending into the screw between the flight sections prevent the forage from rotating with the screw thus causing it to move parallel with the axis of the screw shaft.

The four press sizes used in these early studies were 4, 10, 12, and 16 inches in diameter. The 4 and 10-inch sizes were laboratory models and loaned by the manufacturer to the Everglades Experiment Station. The 16-inch unit was installed and operated at a commercial forage processing plant. The 12-inch press, belonging to the Everglades Experiment Station, was trailer mounted for field operations.

EXPERIMENTAL PROCEDURE

Representative samples of fresh forage, pressed forage, and expressed juices were obtained from a number of laboratory and field experiments and from a commercial operation for a wide variety of crops. However, certain common conditions were met whenever samples were taken: 1) fresh forage samples were all harvested and chopped by standard forage crop harvesters before being pressed; 2) in the case of manually harvested crops and vegetable wastes in particular, efforts were made to stimulate the action of the chopping effect of a harvester as closely as possible; and 3) on all presses the air pressure on the choke cone was maintained at 40 to 50 psi (pounds per square inch).

For convenience, forage crops and potential forage crops were divided into four arbitrary classes: pasture grasses, including paragrass, pangolagrass, Caribgrass, Bermudagrass, St. Augustinegrass, and other pasture type grasses normally grown in the area; other grasses, including oats, sorghum, sweet corn stover, and sugarcane tops and leaves; legumes, including white clover and alfalfa; and vegetables and vegetable wastes such as celery stalks and tops, turnip tops, endive, and beet tops.

RESULTS AND DISCUSSION

Moisture reduction of fresh forage. - The average effect of mechanical dewatering on moisture removal in terms of the ratio of units of moisture to units of dry matter (M/DM) over a wide range of moisture conditions for numerous crops is shown in the graph [Fig. 1]. The M/DM ratio is numerically equivalent to the moisture content expressed on a dry weight basis divided by 100. The dry weight basis of moisture content expression is frequently used in drying studies because the moisture lost is easily obtained by subtraction. For example, if a fresh sample enters the press at 85 percent moisture (wet basis) it contains 5.67 units of moisture per each unit of dry matter (M/DM = 5.67); after leaving the press, M/DM = 2.33 (refer to the graph and the dashed lines). Therefore, under these conditions, after

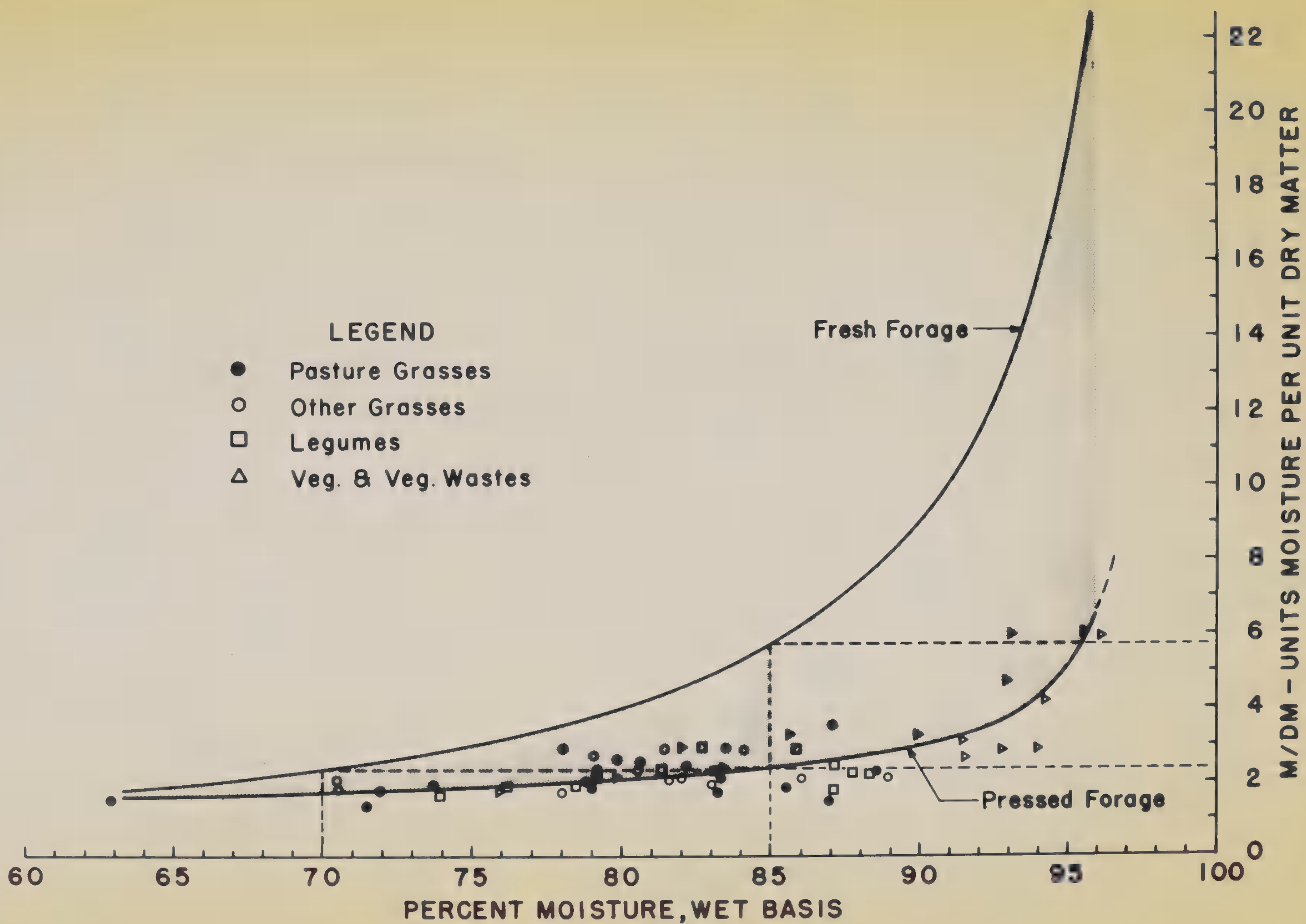

Fig. 1. Units of moisture per unit of dry matter as a function of percent moisture, wet basis, for fresh and pressed forages.

treatment by the press, the forage has lost 3.34 units of moisture or over half the original amount of water. An M/DM ratio of 2.33 is equivalent to 70 percent moisture on the wet basis. Any M/DM figure can be converted to moisture content (wet basis) using the following expression:

$$\% \text{ moisture wet basis} = \frac{M/DM}{M/DM + 1} \times 100$$

Thus in the above example when M/DM = 2.33, % moisture $= \frac{2.33}{3.33} \times 100 = 70.$

The amount of moisture removed by the mechanical dewatering press depends upon several interrelated factors which include initial moisture content, age of crop, type of crop, preparation of material before pressing and others. It is evident from the scatter in the data that, even within the same class, the free hand curve for pressed forage is an average of what occurred when these materials were pressed under the conditions described. However, the curves do indicate that the pressing operation became significantly more important as the moisture content is increased.

The upward trend of the curve in the high moisture region prompted the trial of additional mechanical and chemical treatment of crops prior to pressing. A shredder, similar to a hammer mill but with swinging blades and without a screen, was used to shred and macerate material before pressing. In some cases 1-1/4 percent hydrated lime by weight was added to the shredded materials. Table I shows the effects of mechanical and chemical treatments on the reduction of the M/DM ratio for the crops treated. Shredding significantly reduced the M/DM ratio in the higher moisture crops. The effect on grasses was not so pronounced, though it did help in some cases. Addition of lime further aided in the removal of water.

LITERATURE CITED

1. Pirie, N. W., Jour. Bioch. and Microbiol. Technology and Engineering 1(1): 13-25. 1959.

2. Pirie, N. W., Annual Review of Plant Physiology 10: 33-52. 1959.

3. Pirie, N. W., "Some suggestions on the initiation of work on the use of leaf protein as a human food." Mimeo. Rothsmsted Exp. Sta., Harpenden, Herts., Britain.

4. Tallarico, G. and B. Fagotti.," La conservazione dei foraggi frenchi." Litostampa. Via Brescia 19, 1957, Rome, Italy.

Table I.--Units moisture per unit of dry matter (M/DM) for a representative selection of plant materials that were subjected to several different treatments prior to pressing.

Plant Material and Original Moisture Content, % Wet Basis	Fresh Forage	Pressed Forage		
		Not Shredded	Shredded	Shredded plus 1-1/4% Hydrated Lime
Veg. and veg. wastes				
Celery stalks (95.3)	20.3	8.2	5.0	3.2
Endive (94.8)	18.2	5.8	4.1	2.4
Turnip Tops (93.9)	15.4	2.8	-	-
Sugar beet tops (93.6)	14.6	6.6	3.6	2.0
Mangel (Wurzel) tops (92.9)	13.1	3.6	3.5	2.7
Collards (91.5)	10.8	2.6	-	-
Stock beet tops (90.8)	9.9	4.8	3.0	2.7
Celery leaves (90.6)	9.6	3.2	2.9	1.5
Pasture grasses				
Paragrass (87.4)	6.9	2.3	1.8	-
Alexandergrass (87.0)	6.7	1.9	2.0	-
Napiergrass (85.2)	5.8	2.3	2.0	-
Pangolagrass (82.6)	4.8	1.8	-	-
Caribgrass (82.2)	4.6	2.2	-	-
St. Augustinegrass (80.5)	4.1	2.8	2.2	-
Bermudagrass (77.0)	3.3	1.8	1.8	-
Other grasses				
Oats (88.5)	7.7	2.3	-	-
Sorghum (82.0)	4.5	1.7	-	-
Sweet corn stover (77.9)	3.5	2.4	2.5	-
Legumes				
White clover (88.0)	7.3	1.6	-	-
Alfalfa (82.6)	4.6	2.1	-	-

HANDLING AND STORAGE OF KENAF

By T. F. Clark

The use of green kenaf as a pulp source creates technical and economic problems if the quality of the raw material is to be maintained beyond the growing season. The large amount of moisture present increases the expense for transport of solids and for preservation of these solids. As one phase of preservation study, dewatering or dejuicing has been explored by three techniques to judge their possible potential in preparing material for storage or for immediate processing by a pulp mill.

In two of the techniques, compacting screw presses of different designs were tried. A third technique involved processing kenaf stalks in much the same manner as sugarcane is processed to remove juice and recover sucrose. A single test of dejuicing with cane rolls was tried in 1966 with a three-roll press. More extensive studies were continued in 1967. Green kenaf for these tests was grown in Illinois, Maryland, and Louisiana.

In addition to observations on the effectiveness of these techniques in reducing moisture content, expelled juices and fibrous residues or bagasse were recovered for characterization and appraisal of their quality and utility. Portions of the bagasse are being stored as part of the study to evaluate preservation techniques. Experimental sulfate pulping and characterization of pulps have been undertaken with both fresh material and the bagasse recovered from the dewatering operations.

SESSION ON PULPING AND PAPERMAKING

John N. McGovern, Chairman

KENAF FIBER FOR PAPERMAKING

By Dwight L. Miller

About 10 years ago, the Agricultural Research Service of the U.S. Department of Agriculture initiated a new crops screening and evaluation program. The objective of the program was to find new crops with major plant constituents different from those now available, and with major potential for commercial use. The program emphasized such materials as oilseeds and gums, and included a search for new fiber crops. USDA's Northern Regional Research Laboratory has been responsible for the chemical screening phase of the total program. The Laboratory has also had the responsibility for the complete utilization research study on fiber crops as raw materials for the production of paper and paperboard. More than 1200 samples of fibrous plants from about 400 species have been screened to date.

Some of the facilities we have for evaluating experimental papermaking raw materials include a 10-in. Fourdrinier paper machine and a new continuous Fourdrinier machine on which a 12-in. or a 24-in. trimmed sheet can be produced. The larger machine is illustrated in Figs. 1 and 2.

Kenaf (<u>Hibiscus cannabinus</u>) may be the best and is at least among the most promising new crops for use as a United States pulping raw material. Agronomically, it adapts well to many U.S. growing regions. It is easy to pulp and gives excellent pulp yields. Its fiber dimensions and other essential properties are, in general, equal to or superior to most standard woods. To date, its competitive economics appears to be favorable. The remaining technological properties are believed to be those for which solutions can be found. Thus, kenaf is expected to attain increased commercial importance, in addition to its traditional use as a textile fiber crop for the manufacture of twine, rope, and cloth.

For this discussion, kenaf will be considered as the whole stalk or the whole stalk from which the top leafy portion (up to 2 ft) has been removed. At present, kenaf is grown in many foreign lands for bast fiber only, and the remaining portions are discarded. However, only about 20% of the total dry weight of the stalk is bast fiber. Harvesting and separating this bast fiber require considerable manual labor per unit of production. Such processing is not economical in the United States. In contrast, utilizing

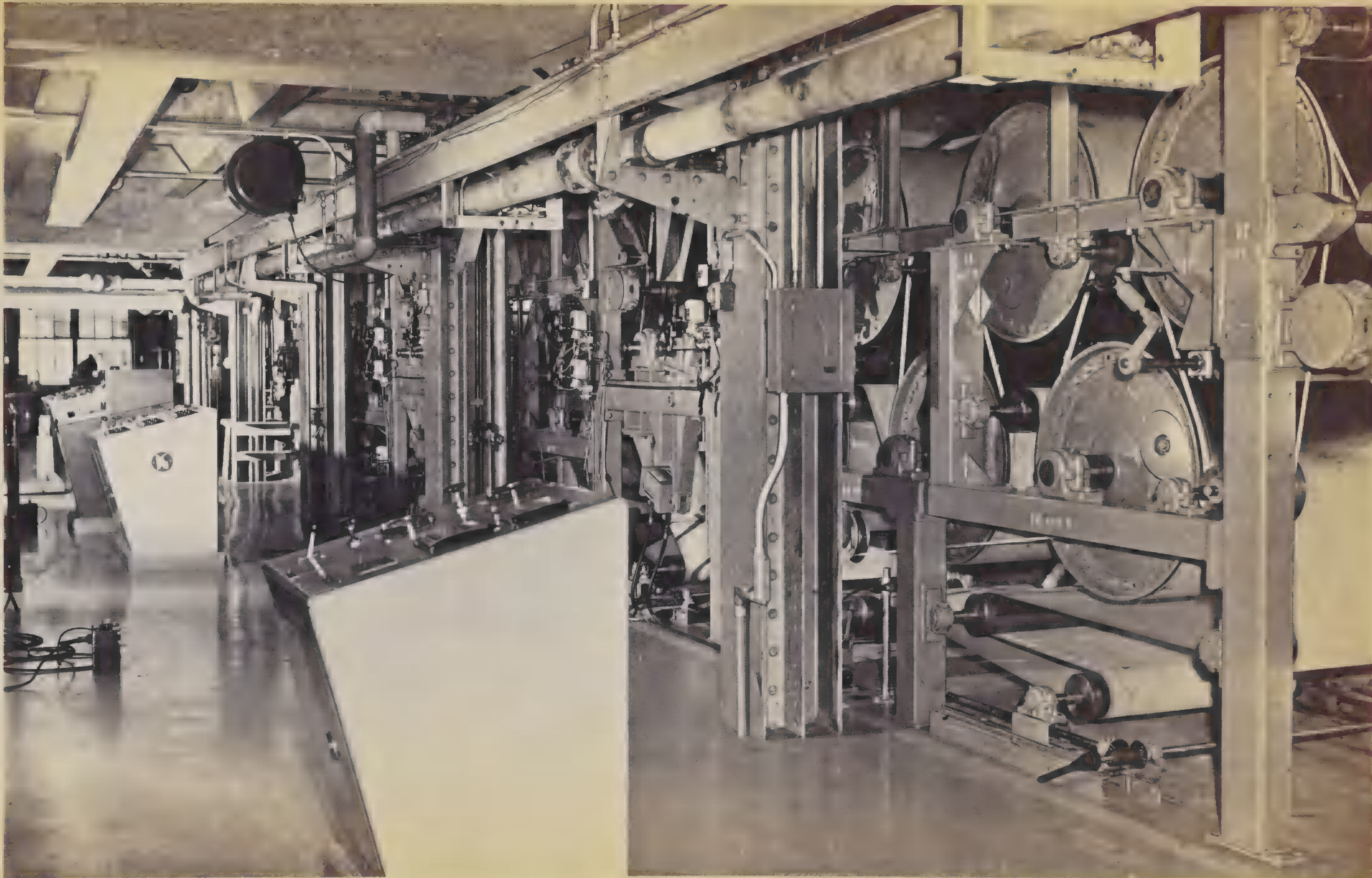

Fig. 1. A general view of new pilot paper machine with adjustable speeds from 50 to 500 ft/min on a straight-through operation.

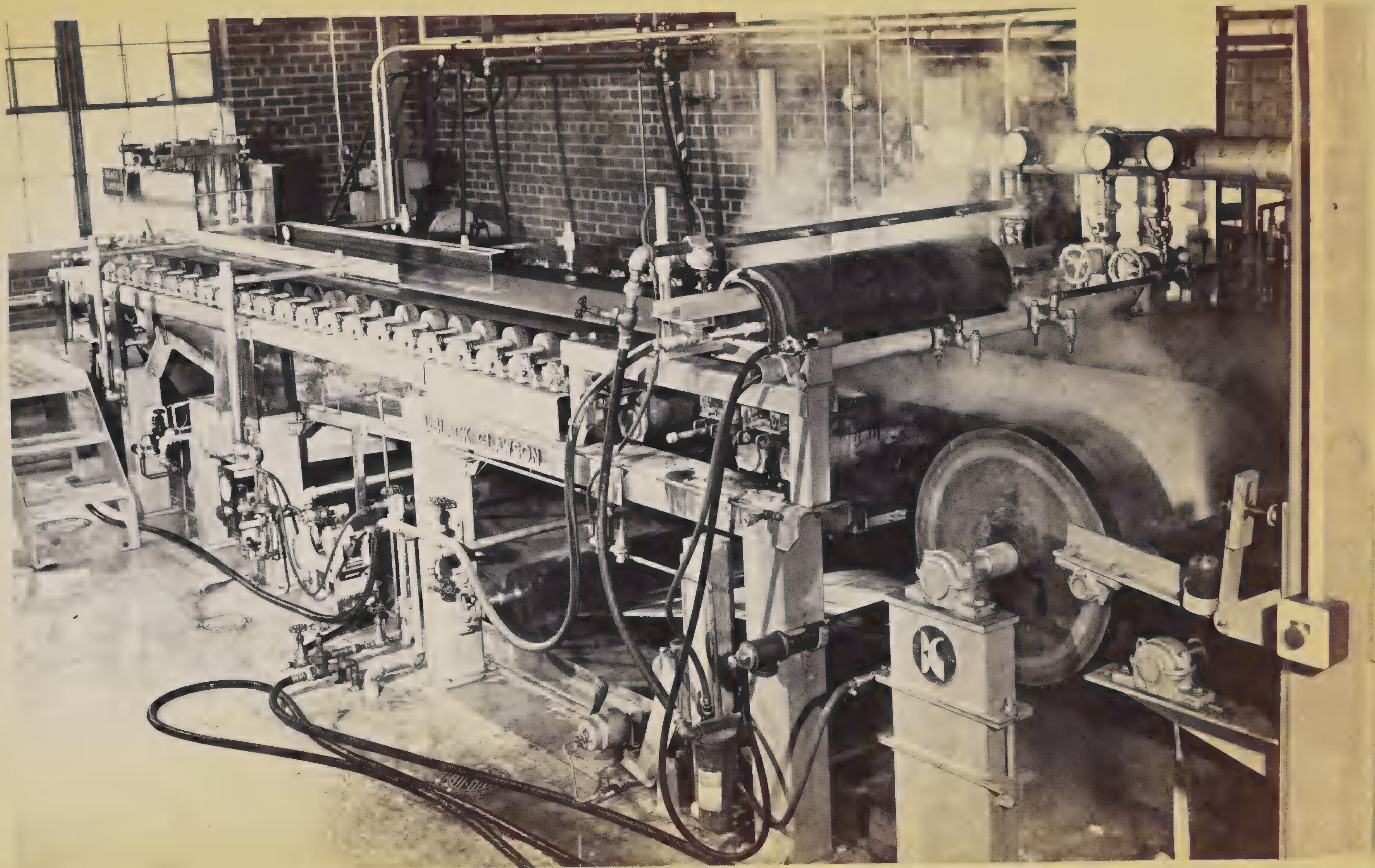

Fig. 2. View of 32-in wire screen on pilot paper machine.

essentially the whole kenaf stalk as a pulping raw material permits mechanical harvesting and processing under efficient U.S. farming practices at minimum and economical costs.

Kenaf annual fiber yields per acre in the U.S. are much higher than woods--usually at least two to three times higher. Yields up to 10 tons or more of dry matter per acre per year have been obtained.

Kenaf may be harvested and pulped green during most of the year in many relatively warm regions, or it may be harvested either green or after frost killing and field drying in certain more northern regions. A distinct advantage is thus realized in the timing of harvesting so as to best utilize available labor and equipment. However, fiber variations under these different conditions must be evaluated and considered in any overall development study. Research studies at the Northern Laboratory have included both green and dry kenaf fibers.

Typical comparative chemical compositions for green kenaf (topped) and for field-dried kenaf (Illinois) are shown in Table I (1). Comparative data for spruce and maple are also included (2).

Table I. Comparative Chemical Characteristics of Mature Kenaf, Spruce, and Maple

Characteristics (Moisture Free Basis)	Kenaf[a/] Green[c/] Florida	Kenaf[a/] Green[c/] Illinois	Kenaf[a/] Dry[d/] Illinois	Spruce[b/]	Maple[b/]
	%	%	%	%	%
Cellulose					
Alpha, corrected	38.4	32.0	38.2	39.4	39.1
Crude	57.3	48.4	56.1	60.0	60.2
Lignin	14.6	13.9	17.1	27.6	23.3
Pentosans	24.6	21.4	23.1	10.6	22.6
Ash	2.5	3.7	1.9	0.5	0.5
Alcohol-benzene solubles	4.7	5.6	3.3	2.4	2.4
Solubles in 1% NaOH	27.9	39.0	27.8	13.9	15.7

a/ Clark, *et al* (1).
b/ Miller (2).
c/ Stalks minus top 2 ft harvested 150 days after seeding.
d/ Defoliated stalks harvested 87 days after frost.

The fibers of whole kenaf are affected by age, growing location, and climatic conditions. Comparative fiber characteristics are shown in Table II (1). Kenaf fiber width is about the same as maple but is narrower

Table II. Comparative Fiber Characteristics of Mature Kenaf, Spruce, and Maple

Characteristics	Kenaf[a]			Spruce[b]	Maple[b]
	Green[c]		Dry[d]		
	Florida	Illinois	Illinois		
Fiber length, mm					
Bast	2.16	2.32	2.52		
Woody	0.45	0.48	0.51		
Combined	1.15	1.22	1.21	3.16	0.76
Fiber width, µ					
Bast	13.6	15.7	15.9		
Woody	32.0	30.1	30.7		
Combined	--	--	--	43.8	20.2

[a] Clark, et al (1).
[b] Miller (2).
[c] Stalks minus top 2 ft harvested 150 days after seeding.
[d] Defoliated stalks harvested 87 days after frost.

than spruce. Fiber length for kenaf averages about 1.2 mm compared to about 0.76 mm for maple and 3.16 mm for spruce wood. Kenaf bast fiber averages about 2.5 mm in length. Bast fiber comprises about 20% of the dry weight of the stalk. The whole kenaf pulp contains from 30-40% bast fiber, because bast fiber pulping yields are normally higher than the remainder of the stalk.

Typical experimental results from pulping green and dry kenaf compared with typical woods are summarized in Table III (1, 2). Kenaf and wood pulp yields are comparable. Based on limited data, green kenaf gives slightly lower yields than field-dried material from the same region. However, the growing location may be significant in that Florida-grown kenaf gave consistently higher pulp yields than Illinois-grown kenaf. Kenaf proved easier to pulp than wood in all studies.

Table III. Chemical Pulping of Kenaf[a] as Compared to Wood

Property	Kenaf[b]			Wood Pulps[c]	
	Green[d]		Dry[e]		
	Florida	Illinois	Illinois	Hardwood	Softwood
Crude yield, %	58.0	49.1	52.7	52.0	58.0
Screened yield, 8-cut, %	54.8	46.9	49.6	--	--
Fines, %	3.1	2.1	3.1	--	--
Beater evaluations (unbleached)					
Characteristics at 600 ml S-R					
Burst factor, $(g/cm^2)/(g/m^2)$	63.4	72.0	73.5	25	62
Breaking length, m	11,800	11,400	11,600	4700	9300
Tear factor, $g/(g/m^2)$	80	94	93	43	120
Folds, Schopper No.	1360	1210	920	100	1600

[a] Cooking 2 hr at 170°C, 21% sulfate chemicals; 16.3% active alkali as Na_2O; 10.0% sulfidity.
[b] Clark, et al (1).
[c] Miller (2).
[d] Stalks minus top 2 ft harvested 150 days after seeding.
[e] Defoliated stalks harvested 87 days after frost.

The handsheet data show paper prepared from kenaf is stronger than paper prepared from hardwood and, except for tear, comparable to paper from softwood. However, kenaf papers are relatively tight and nonporous in contrast to those from wood. Consequently, kenaf products have certain distinctive characteristics in addition to improvements in the standard properties.

Based on investigations to date, the overall status of kenaf fiber for papermaking may be summarized as follows:

Raw material demands in the paper industry are rapidly increasing, and the available materials are becoming more expensive.

Wood pulp now constitutes more than 97% of all papermaking raw materials. The other 3% comes from rags, bagasse, flax, manila stock, straw, cotton fibers, and hemp.

Agricultural residues and wastes have become less economical raw materials, and the supplies have been uncertain. Their usage is expected to continue to decrease.

So far, no annual plants have been grown in the United States exclusively for use as a pulp source.

Research results and economic studies show that kenaf is a potential papermaking raw material in certain regions of the U.S. where annual yields are greater than wood.

Kenaf stalks can be processed to produce pulps with properties and performance equal to most softwoods and superior to most hardwoods. It may also be used as a blend to improve lower quality pulps. Kenaf papers have many characteristics difficult to obtain from wood.

Many significant and important problems have been resolved in the development of this new crop, but many still remain to be solved.

We conclude that kenaf fiber may become an important commercial raw material for papermakers.

LITERATURE CITED

1. Clark, T. F., Uhr, S. C., and Wolff, I. A., Tappi 50 (11): 52A (1967).

2. Miller, D. L., Tappi 48 (8): 455-459 (1965).

PULPING OF GREEN KENAF FROM ANAEROBIC STORAGE: EXPLORATORY TESTS

By T. F. Clark

Anaerobic storage as a means for preserving fiber quality of green kenaf for bleachable sulfate pulps was explored on a laboratory scale during two crop seasons in Illinois. Ensiling was simulated by packing chopped kenaf stalks into a plastic container or wooden barrels. Effectiveness of a storage condition was judged by analytical results, sulfate pulping (21 percent total chemicals at 10 percent sulfidity), and pulp characterizations for raw and stored materials.

During the first crop season (1965), a single test was made with fresh green kenaf stalks minus the top 1-1/2 feet. These stalks chopped to 1/2-inch were tamped into a 50-gallon plastic drum and covered with polyethylene film. Two months later portions of the mold-free contents were evaluated as removed from the container, after neutralization, and after being washed to remove a substantial quantity of slime and "silage" acids. Pulping efficiency, basis solids charged into a digester, was less for "silage" than for original green material but improved after neutralizing or washing of the "silage." Yield of screened pulp after the wash treatment was 48 percent, permanganate number was 23, and the bleach requirement to reach 70 brightness was 12 percent expressed as Cl_2. Physical properties of the unbleached pulp from washed "silage" were superior to those of a hardwood sulfate and comparable to those, resistance to tear excepted, of a softwood sulfate.

In the second season (1966), the study was extended to include complete green stalks and stalks harvested 16 days after frost. Wooden barrels were used for storage to permit periodic tests on samples removed via borings through the staves. After 4 months the "silages" were evaluated as in 1965. The effects of the shorter growth period in the second season (approximately 120 versus 150 days) are apparent in the composition of materials stored. The washing treatment again was effective in improving quality characteristics of "silages." Pulp produced from washed "silage" of stalks harvested 16 days after frost was obtained in 50 percent yield (screened), had a permanganate number of 16, and had a bleach requirement of 7 percent (as Cl_2) for 75 brightness. Quality characteristics of this pulp, tear resistance excepted, were superior to those of a southern hardwood kraft.

Results of this laboratory-scale exploratory study are encouraging and suggest that storage under anaerobic conditions might be useful in preserving green and recently frosted kenaf for papermaking purposes. In addition to appraisal of effectiveness in quality preservation is the need for establishing material balances whereby the economics of anaerobic storage might be assessed.

RESULTS OF A MILL SCALE TRIAL OF KENAF

By Gary W. Guttry

Hudson Pulp and Paper Corporation at Palatka, Florida, has been actively interested in kenaf as a potential fiber source for several years. In 1965, the Woodlands Division planted several acres of kenaf near the Palatka mill site. As this stand matured, the Woodlands and Technical Divisions cooperated to obtain information concerning its development and potential.

Included were a series of experimental cooks in the Pulp and Paper Technical Service pilot plant. These pilot plant cooks were made with the primary goals of determining:

1) The feasibility of pulping kenaf by the sulfate pulping process.

2) The compatibility of kenaf pulping in the sulfate pulping process employed at Palatka.

3) Could kenaf pulp be utilized in some manner by Hudson?

The results of the pilot plant work led to the following conclusions:

1) Kenaf could be pulped under conditions very similar to those routinely employed in the Palatka mill.

2) The pulp yield, on an ovendry basis, was equivalent to that obtained from the mill's normal softwood and hardwood supply.

3) The kenaf pulp produced was substantially inferior to pine pulp in tear, mullen, and tensile properties and inferior to hardwood pulp in mullen and tensile. It was, however, superior to hardwood in tear value. Additionally, the pulp was hard and had a somewhat metallic feel when made into hand sheets.

4) The freeness and drainage of the pulp was quite slow and would present a problem at the washers and deckers.

5) Assuming the Woodlands Division could deliver green or dry kenaf to the mill on an economically advantageous basis, the first problems to be encountered would be in the Woodyard. Equipment such as the chain conveyor which evacuates the chip pit would undoubtedly present a problem. The major concern however, would be how to get chopped kenaf out of the tile chip towers. If you have handled kenaf you realize how it would stick and bridge in a silo.

6) The potential of kenaf pulp for Hudson would probably be restricted to select low level substitution or to production of a special market kenaf pulp.

MILL TRIAL

At this point, the following situation developed. Kenaf sufficient for a mill trial was available; the pilot plant evaluation was considered as encouraging; and some planned maintenance combined with normal pulp mill flexibility offered a rare opportunity for an economical mill pulping trial. With a pulp dryer, the kenaf could be pulped, dryed on the pulp dryer, and stored for later use as the opportunity occurred.

A healthy spirit of curiosity and cooperation prevailed and management decided a mill scale trial should be made.

The kenaf to be utilized in the trial contained two separate stands totaling about ten acres. Six acres were planted in April, 1965, and at the time of the trial was fully mature. Stalk heights in this stand averaged twelve feet. Stem diameters averaged 3/4 inch overall and 1-1/2 inch at the base. The other four acres were planted in July, 1965, and was considered immature at the time of the trial in October. This younger stand averaged seven feet in height and 3/4 inch in base diameter. It was estimated that the older stand contained 90 tons and the younger stand 25 tons of green harvestable kenaf.

The plan for the trial was for Woodlands to harvest the kenaf and deliver it to the purchased chip pit over a 24 hour period. It would be blown directly to an empty silo, fall straight through, and be deposited on the digester loading conveyor belt.

Harvesting and Delivery of Kenaf

Prior to harvesting, the kenaf was sprayed by plane with a defoliant. Harvesting was then accomplished with two forage harvesters. The harvesters were adjusted to produce stalk cuts of slightly more than 1/2 inch length. Neither of the machines fulfilled production expectations and one did not produce the clean stalk cuts desired. Excessive turn-around time on the short rows and clogging of the feed rolls of the harvesters were major factors in reducing production.

Initially, plans were to deliver the chopped kenaf to the purchased chip pit at the mill in field wagons of five ton capacity. As you might expect in such a trial, it was not long before an axle on one wagon broke. The loads were then reduced to four tons. In a dry run prior to the trial, it

was found to be almost impossible to back the U-Clamp connected field wagons up the ramp to the chip pit unloader with a truck or tractor. A winch truck had to be stationed across the pit to pull them into position for dumping. When loading fell behind schedule, Woodlands set up field lights and worked into the night of the first day. They also obtained dump trucks to augment the wagons. The greater speed and mobility of the trucks helped smooth out operations although they had a capacity of only 2 to 2-1/2 tons. Competition from purchased chip trucks at the chip pit necessarily caused some delay on the second day.

A total of 87 tons of chopped kenaf was finally delivered. This weight was determined from gross and tare scale receipts on the vehicles.

Wood Yard Handling and Digester Loading

For the trial, one 3300 and one 4000 cu. ft. digester were utilized, one cook being made in each.

The operation from the chip pit to the digesters was relatively smooth. The kenaf did string up on the chain conveyor which evacuated the chip pit. At times the stringing was severe enough to cause concern about the chain jumping its sprocket. The only other problem was in working around normal digester loading from the other silos which fed to the conveyor belt going to the digester room.

After completing the loading of the second digester, the first was inspected. It was found to have settled sufficiently overnight to allow addition of five more tons of kenaf. The final load to the 3300 cu. ft. digester, the one which settled, was estimated at 43.0 tons. The normal chip load is about the same. The final load to the 4000 cu. ft. digester was estimated at 43.9 tons. The normal chip load is about 50 tons.

In addition to the somewhat disproportionate loads to the two digesters, about half of the load in the larger one was from the young stand of kenaf which contained more moisture. Grab samples from the chip conveyor showed an average of 71 percent ovendry moisture for the mature kenaf and 75 percent for the younger or immature stand.

Because the tonnage difference was not too great and digester size had little bearing on the final results, confusion will be avoided by referring to them as Digester or Cook Nos. 1 and 2. No. 1 will be the smaller digester and No. 2 will be the larger one which contained the young kenaf.

Cooking Operation

The digesters were left without liquor charge overnight. On the third morning, 21 percent active alkali, based on ovendry kenaf solids, was charged to each digester. No black liquor dilution was added because:

1) The combination of bound moisture and white liquor gave a 5:1 liquor to wood ratio, and

2) There was a possibility that the kenaf might float when the steam was introduced into the direct steaming digesters.

No. 1 was then steamed on a 90 minute to pressure cycle using an automatic pressure control cam designed from the pilot plant work. The cam worked well with some assistance at the relief line and No. 1 came on pressure right on schedule at 110 psi and 344°F. After two on-pressure digester samples, it appeared that very little pulping was occurring. The active alkali charge to No. 2 was increased to 25 percent on the probably premature assumption that either weight, moisture, or liquor measure was off in some manner. By the fourth check on No. 1, however, it was found that very rapid pulping was suddenly occurring. No. 1 was then blown after 95 minutes on pressure. A dirty blow was obtained and the digester had to be reblown. Possibly, some floating of the kenaf may have occurred and contributed to the dirty blow although no raw kenaf could be found later in the system.

No. 2 Digester was then steamed. It came on pressure after 85 minutes. Rapid pulping occurred and a clean blow was made after only 10 minutes on pressure.

Total pulp yields were estimated at 6.27 tons on Cook No. 1, which had a blow permanganate number of 17.5 (40 ml. basis) and 5.55 tons on No. 2 which had a 14.4 permanganate number.

Prior to the trial, the blow tank and the stock chests throughout the system to be used were emptied and flushed where practical in order to isolate the kenaf pulp.

Screening and Washing

After both cooks were in the blow tank, the brown stock screening and washing operation was begun. The washer line used was a four stage Impco washer with 8 x 12 ft. drums. It is preceded by two Impco A25 hot stock screens and followed by a conventional 8 x 10 ft. valve type Impco decker. During the trial, the 4th stage washer drum was out of service.

Difficulties were experienced immediately at the hot stock screens. The screen with the 90-cut plates sealed over so the 117-cut unit was used with greatly increased dilution. Except for the seal over period, it is believed that very little of the pulp was rejected since there were few rejects in the blow samples (perhaps two percent in No. 1 and less than one percent in No. 2). These rejects were mostly long bast fibers which would string up in the screen plates but which were eventually swept through or rejected, refined, and returned to the system.

As expected, the pulp drained very slowly on the first stage washer drum and seal-over was a problem. Drainage was much better on the second and third stage drums. The production rate off the washers averaged only about three tons per hour with a high rate of about five tons per hour near the end of the run. It is expected that ten tons per hour could be washed on this line once the operators had a chance to gain experience (the normal maximum rate for pine pulp would be about 16 tons per hour). A fourth stage wash would undoubtedly be necessary to properly clean such slow draining pulp.

A washer aid was used at the start of the run and appeared to aid drainage in the first vat. It was used to excess in an effort to get recirculation and caused excessive dewatering and roll-off on the second stage so its use was discontinued. It is believed that a washer aid could be of considerable value in washing kenaf when properly used.

The brown stock decker was able to handle the kenaf pulp satisfactorily at rates up to about ten tons per hour. Some foaming did occur, but it was not a serious problem.

Drying of the Pulp

From the decker chest, the pulp was transferred to the Pulp Dryer system. This is a 9-pass, 250 ton per day Flakt dryer which operates at speeds up to 115 fpm. The wet end includes a 130 in. width, 8 ft. diameter Impco cylinder mold, two Impco straight through presses, and a Bauer centri-cleaner system. There is an open draw of about 4-1/2 ft. between the cylinder mold and the first press with only one transfer roll.

A sheet of pure kenaf sufficiently strong to transfer across this draw could not be formed. The slow drainage and foam prevented the formation of a thick sheet and hindered the formation of a tight sheet on the mold press. Defoamers were tried and the Bauer cleaners were by-passed in efforts to form a transferrable sheet.

After two hours of effort and considerable loss of kenaf pulp, it was determined that unbleached pine pulp would have to be added in order to form a transferrable sheet. At a hastily reached level of 40 percent pine, a sheet was transferred. Hand-feel of the pulp had definitely changed from that characteristic of kenaf to that characteristic of pine.

Continuing our luck, the commercial power supply then being utilized failed twice before the sheet came out of the dryer section. Eventually, 34 bales (about seven A. D. tons) of the kenaf-pine mixture were salvaged and stored. Fiber counts showed the pine content to range from 40 to 60 percent. The stored pulp was therefore considered to be a 50-50 mix of kenaf and pine.

Analyses of Pulps

The test results from beater runs on kenaf, 50-50 kenaf-pine, pine, and bleached hardwood pulps showed the mill produced pure kenaf pulp to be:

1) Significantly inferior to pine pulp in mullen, tear, and tensile.

2) Inferior to hardwood pulp in mullen and tensile.

3) Superior to hardwood pulp in tear.

The tests showed the 50-50 kenaf-pine mixture to be:

1) Proportionally inferior to pine in mullen and tensile.

2) Essentially equal to pine in tear.

3) Superior to hardwood in mullen, tear, and tensile.

Of potential importance is the beater time (or refining power) required to develop a given freeness. Freeness development versus time was about equal in the mid-range of each freeness curve but initial freeness development of pine was less rapid and that of kenaf more rapid than the norm. A 50-50 mix of pine-kenaf has a correspondingly lower initial freeness than pine and more rapid freeness development than pine or hardwood. If acceptable paper can be produced with kenaf added, then pure or mixed kenaf might be utilized in grades where refining capacity is a limiting factor.

FOURDRINIER MACHINE TRIAL

In December, 1965, 6-1/2 tons of the kenaf-pine pulp were used to produce a 30 lb. kraft paper in a trial on No. 2 Paper Machine. One set designated as having a high kenaf content was produced. Maximum final kenaf content was 22 percent.

No. 2 Machine is a Pusey and Jones Fourdrinier machine which normally produces light weight unbleached paper grades and, to a lesser extent, a wide range of bleached kraft paper grades at trims up to 220 in. and speeds to 1900 fpm. It is a fairly conventional machine except for an inverted pickup and transfer press and a cloverleaf first and second press.

With only 6-1/2 tons of the kenaf-pine pulp, the machine system chests were pulled as low as possible during normal operation to isolate the trial pulp. The kenaf-pine pulp was repulped and then transferred through the primary refiners into the machine system as rapidly as possible.

Almost immediately after the kenaf entered the refined stock system, couch vacuum, basis weight, and sheet moisture at the couch increased. Refining was successively decreased until there was practically no load on the primary refiners and only about half-load on the secondary refiners. These reductions increased the refined stock freeness from 330 cc (Canadian Standard) for the pre-trial pine pulp to 450 cc for the kenaf-pine pulp yet the dry line did not shift back up the wire to its original position.

Oddly, even with the higher basis weight and higher moisture off the wire, the moisture of the kenaf-pine set at the reel was 10 percent lower. Operating personnel commented that the sheet appeared to dry more readily than the pure pine sheet.

Product Quality and Interpretation of Results

As stated above, only one set containing a good percentage of kenaf was produced due to the limited supply of kenaf-pine pulp. Such a brief trial coupled with the drastic change in refining during the trial necessarily make the results somewhat questionable. For the record, however, tests on the kenaf set showed the following when compared to pre- and post-trial reel tests.

1. Basis weight increased 1.3 lb. (4%).

2. Caliper increased two points (6.5%).

3. Percent mullen decreased - 44% vs. 56-58%.

4. Percent C.D. tear decreased - 187% vs. 193-195.

   Percent M.D. tear increased - 200% vs. 156-167%.

   Percent total tear increased - 388% vs. 350-358.

The decreases in mullen and overall increase in tear are of course consistent with a decrease in refining, i.e., an increase in freeness. Interpolation of the results to account for the increases in basis weight and freeness would probably be misleading. Because of the above and the brief duration of the trial, valid conclusions appeared to be limited to:

1. At similar Canadian Standard Freeness levels, even a small percentage of kenaf pulp in regular pine furnish drastically reduces on-wire drainage.

2. In order to develop the strength properties of a kenaf-pine pulp mixture through proper refining, a reduction in machine speed or wet end modifications would be necessary to compensate for the reduction in drainage.

ECONOMICS AND GENERAL COMMENTS

The favorable estimated delivery cost of kenaf can be misleading from the production point of view. The other plus factors noted for kenaf are: 1) it is an annual crop; 2) the pulp yield based on O.D. solids is comparable to pine and hardwood; 3) the pulp is easily refined to a low freeness.

Even these three factors are not necessarily straight forward advantages. As an annual crop, kenaf would not be available from the field year round. The O.D. solids content of raw kenaf is only about 30 percent so the yield per ton of raw material is much less. The low initial freeness, which is a factor in ease of refining, restricts the use potential of kenaf pulp and increases the problems associated with processing it.

The negative factors for kenaf, primarily of economic importance, are noted below. These factors are based on a ton for ton replacement of regular unbleached pine or hardwood pulp with kenaf pulp in the Palatka plant:

1) The pulp yield per ton of green raw material is only about half that of pine or hardwood. The pulp yield per digester is, therefore, about half that of pine or hardwood (less oven dry raw material per digester).

2) Kenaf requires 10-25 percent more active alkali per ton of pulp.

3) Batch digester load and cap time per ton of pulp is at least doubled.

4) Digester steam requirements per ton of pulp are doubled.

5) Weak black liquor production per ton of pulp is 50 percent greater and the liquor is of lesser solids content. Evaporator steam requirements would therefore be about 60 percent greater.

6) By-product credits for turpentine and tall oil are eliminated.

7) Washer production rate would be about 70 percent of normal.

Based on the premises that:

1) Existing pulp mill equipment could be used without loss of production and,

2) Kenaf delivery and digester loading time could be decreased to a rate equal to that for pine or hardwood,

it is estimated that the cost of slush kenaf pulp would be roughly 90 percent of the standard cost of regular pine.

The premise of using existing equipment on the above basis is, of course, impossible. To replace a significant amount of pine or hardwood pulp with kenaf pulp would require:

1) A special raw kenaf storage area and chip pit.

2) Additional or modified digester loading equipment.

3) Additional labor at the digesters.

4) Modified washing facilities.

5) Additional evaporator capacity.

6) Additional recovery capacity.

7) Paper machine modifications.

The above facts and conclusions do not eliminate the possibilities of using kenaf at Palatka on a small scale. This could be accomplished by blending, either in or after the digesters.

PULPING AND PAPERMAKING - PANEL PRESENTATIONS

John N. McGovern, Moderator

PRETREATMENTS FOR KENAF

By Joseph E. Atchison

It is a pleasure for me to be here at this conference and to hear of the many positive steps which are being taken to develop the use of a potentially important non-wood fiber for the manufacture of pulp and paper. As many of you know, I have been beating the drums for the use of various non-wood fibers for many years and I believe the time is rapidly approaching when the economics will be right for their use in the United States as well as in many other countries where they are already used to a considerable extent.

My own activities for the past 18 years have been concentrated in the foreign field, predominantly in the utilization of non-wood fibers for pulp and paper manufacture. My first interest in kenaf came about from the standpoint of possibly using the bast fiber only for the long fiber component in a 100 ton bleached bagasse pulp and paper mill in Northern Argentina, in an area where experimental plantations of kenaf were also being grown.

At that time, there was a severe shortage of foreign currency in Argentina and they had no local long fibered wood pulp available. It was, therefore, felt that it might be possible to use the kenaf ribbons to produce long fiber pulp which could be blended with the short fibered bagasse pulp up to the 10% to 20% required to get good running conditions on the paper machine.

An economic study indicated that the bast fiber ribbons at an estimated cost of about $0.04 per pound at that time could be converted into pulp at a cost competitive to imported bleached kraft wood pulp which was very expensive at that time.

Unfortunately, the kenaf pulp mill was not installed in this case, but I do believe that in some areas of the world it will definitely prove to be economical to use kenaf ribbons alone for production of long fibered pulp as a blending pulp with bagasse, straw, and other short fibered materials.

Now based on what I have heard here and what I have been reading of the pulping work carried out at Peoria, I believe that the use of whole kenaf stalks might also prove to be very promising in some of the developing countries which our United States AID program are attempting to help.

However, I am still not completely convinced that we should attempt to use both components of the kenaf stalk for the same purpose. There may be some merit in separating the bast fiber from the woody and pithy portions of the stalk, than treating each part separately for the type pulp for which each might be specifically suited. There are, of course, several approaches to this possible method of utilization. One might involve the use of a harvesting and ribboning machine in the field, with storage and handling of the two components being separate from the beginning. The other possibility might involve the forager-harvesters, followed by bulk storage and separation of the two components by some classification method at the pulp mill before pulping.

By either of these means the bast fiber could be utilized for pulp to be used in a blend for high strength papers, while the short fibered woody pithy material might be used for mechanical pulp or as part of a corrugating medium furnish. As some of you know, the use of bagasse was held up for fifty years because all efforts to use it involved the use of the whole bagasse without separation of the pith. It was recognized by the technical experts that these two components were different and to get a good quality pulp it was necessary to remove the pith, and patents on pith removal were granted as early as 1912 or before. However, all of the mills which were built to utilize bagasse failed to carry out this separation of pith, and as a result all of these early efforts failed because the product was not acceptable on the market and because of the tremendous operating problems that the presence of the pith caused. It was not until the two elements of bagasse were separated, before pulping, that this raw material was successfully used. There are now 35 to 40 bagasse pulp mills in operation, ranging from 10 tons to about 200 tons daily.

In fact, in the case of kenaf, I am not so sure that it would not be a good idea to remove some of the finest material in the woody pithy fraction before doing any chemical pulping in that fraction. On the other hand, this material might be converted into mechanical pulp, without the use of chemical and without even bleaching if the bast fiber is first separated from it.

The use of bulk storage of kenaf is especially interesting and I believe that from the standpoint of commercial operations, the material stored in this way will give better results in the pulp and paper mill than the fresh kenaf. I have found, for example, that bagasse fresh from the sugar mill contains certain gums and sugars that cause great difficulty in the washers and also slows up drainage on the paper machine. By contrast, after this material has been stored for a few months, either in bulk storage or in bales, these materials either disappear or their character changes so that

the washing rate is better. There is less foam and the drainage rate on the paper machine is much better. This does not show up in the pilot plant work but is very evident in commercial operations.

I believe these same phenomena might be true with kenaf. Likewise, the presence of pith and fines does not cause so much trouble in a pilot plant operation but shows up very quickly in large scale operations in reducing production rates.

In summary, I would like to see work being done on separating and pulping the two components of kenaf separately as well as pulping the mixture. I believe some variation of this procedure may prove to have some real merit.

STORAGE OF RAW KENAF

Notes on the talk of G. Rowlandson*

Mr. Rowlandson referred to his experience with kenaf when he was associated with Kimberly-Clark Corporation at Coosa Pines, Alabama. Two problems were under consideration: new sources of papermaking fibers and storage of kenaf.

Mr. Rowlandson continued with an illustrated account of the operation of the Ritter Process for preservation of sugarcane bagasse with a special biological liquor. During the period of wet storage pith is loosened from fiber bundles so that its subsequent removal is facilitated. Removal of pith and water-solubles from the bagasse contribute to lower chemical consumption, shorter cooking times, better yields from the digester, and quality pulps. Color slides illustrated operations at the Ngoye Paper Mill, Zululand, South Africa.

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* Prepared by T. F. Clark

KENAF AS A SOURCE OF KRAFT OR SEMICHEMICAL PULP

By W. J. Nolan

We have had no experience at the Florida Pulp and Paper Laboratory in the pulping of kenaf. What I have to say on the subject is based only on a review of the publications of the Peoria laboratory of the U.S. Department of Agriculture, a few chlorine dioxide purifications of the wood and bast portions of kenaf stalks, and our past experience in the pulping of wood and of annuals such as bagasse and cotton stalks.

The work at Peoria has shown that kenaf kraft pulp can be produced at yields of close to 50% with tensile and bursting strengths comparable to soft wood kraft and tear properties lower than soft wood but considerably higher than hardwood pulps. Fibers from the bast fraction appeared to be about 2.5 mm long while the fibers from the wood fraction averaged about 0.60 mm. Lignin content of the stalks was found to be about 17% while pentosan content was about 20%. All of these facts point to a raw material with very good papermaking potential.

Our own experience in the pulping of bagasse and cotton stalks has led us to believe that the pulping of annual cellulosic materials presents a problem of low freeness and a sensitivity of the pulps to normal refining procedures which can result in brittle and "tinny" papers. For example, whole bagasse converts to kraft pulps with Canadian Standard freeness as low as 300 ml. Properly depithed, bagasse can be cooked to pulps with as high as 600 ml freeness. With depithing procedures it has been possible to produce cotton stalk pulp with freeness of about 500 ml. The Peoria kraft pulps had freenesses in the 500-550 ml range.

An examination of the cross-section of dried kenaf stalks indicates that pith is concentrated in the central tube of the stalk. However, the cross section of freshly cut stalk shows the woody portion of the kenaf to be very soft. This soft structure suggests that pith may be interspersed between the cellulose fibers in the wood, somewhat similar to the structure of bagasse.

In an attempt to check out the presence of pith in the woody portion of the stalk, a few chlorine dioxide purifications were undertaken at the laboratory. Several sections of air-dry stalk grown by Dr. Killinger[1]

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[1] G. B. Killinger, Agronomist, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida 32601.

in 1966 (EG 71), were peeled of their outer bast layer. It was found that these stalk sections were 31.8% bast, 68.2% woody and central pith. The woody material was cut in 1 in. lengths and split. The central pith was removed. The woody pieces were then cut lengthwise into matchstick size. Both woody and bast fractions were subjected to four successive chlorine dioxide treatments. To each 25 g sample of dry material were added 25 g sodium chlorite and 5 ml glacial acetic acid. The suspension was brought to 65°C and held for 6 hr. Since supersonic vibration equipment, similar to that used at Peoria for fibrillation, was not available, fibrillation was attempted after each treatment by mixing in the TAPPI pulp mixer. The small sample permitted a mixing consistency of only about 1.5%, resulting in very inefficient fibrillation. Even after four successive treatments the samples had not been completely reduced to individual fibers.

However, it was found that the purified woody fibers contained a portion of very fine, non-fibrous material, probably pith. Samples of suspensions of the purified woody and pith fibers are available for inspection.

A pretreatment of freshly harvested kenaf, similar to that developed for cotton stalks, is suggested as a means for removing all of the central pith and part of the pith in the wood itself. The kenaf stalks should be cut into sections 1.0 to 1.5 in. long. If the stalks are still soft, containing 75-80% moisture, they might be passed directly through an attrition mill equipped with spiked toothed plates. This treatment should reduce the woody fraction to large fiber bundles. If the harvested stalks are dry, heating in a dilute sodium carbonate solution at 212°F will soften the stalks.

The fibrillized material should then be passed over an inclined screen equipped with travelling sprays. The screen may be of 10 to 16 mesh. Very fine material will be washed through the wire. A considerable amount of water solubles will also be extracted from the kenaf. The fibrous, wet material might then be sent to outdoor storage, using compaction with bulldozers, similar to the practice in outdoor storage of wood chips. The addition of appropriate nutriments, such as used in the Ritter process for bagasse storage, might be used for removal of residual pith and maintenance of fiber quality during long term storage.

The treated kenaf bagasse can be subjected to either kraft or NSSC pulping. The properties of the kenaf, combined with the high degree of subdivision caused by the pretreatment, make the use of high speed continuous pulping equipment essential. It is felt that the material may be pulped satisfactorily by the kraft process in 15 min or less; by the NSSC process, in 30 min or less. It is hoped that the pretreatment might result in fully cooked pulps with Canadian Standard freeness of 600 to 650 ml.

It is suggested that pretreatment experiments along the lines just outlined be undertaken. Such procedures, through pith removal, should result in improved pulp quality. These studies might also lead to the solution of the long time storage problem. If kenaf cannot be economically stored over a 12 month period, it cannot become a practical source of paper-making fibers.

A few additional tests at the laboratory indicate that bast content of the stalk may be somewhat higher than anticipated. As mentioned earlier, the dried stalks grown in 1966 by Dr. Killinger contained 31.8% bast and 68.2% woody and pith. A single stalk cut from Dr. Killinger's 1967 planting (taken in August, 1967) showed, near the base of the stalk, a bast content of 46.5%; woody, 51.8%, and central pith, 1.7%. In October, 1967, 100 stalks of Dr. Killinger's planting of Everglades 41 were cut. Three of these stalks, about 1-1/4 to 1-1/2 in. diam. at the base, were tested for bast and woody fraction. Only the 7 ft sections at the base were tested. They were found to contain 29.2% bast, 70.2% woody and 0.6% central pith.

It may be that the amount of bast fiber in the stalk depends on the variety of kenaf and the growing conditions employed. Since maximum bast content means maximum pulp yield and quality, efforts should be made to produce those varieties which will be heaviest in bast fiber.

Incidentally, the yields obtained from the chlorine dioxide purifications mentioned earlier may be of interest. The completely delignified bast fraction showed a yield of 67.8% of the original dry bark or bast. The delignified woody (no central pith) fractions showed a yield of 59.6%.

It is hoped that the Pulp and Paper Laboratory here at the University will be able to undertake extensive research on the kraft and neutral sulfite pulping of this material. The laboratory is particularly well equipped for the pretreatment experimentation mentioned earlier. We are also in a position to investigate very short, constant temperature cooking as well as conventional batch procedures. However, the present University budgetary situation is such that very little state-sponsored research can be undertaken. It is hoped that other sources of funds, either industrial or governmental, can be found to sponsor such a program.

I apologize sincerely for presenting such qualitative and speculative material at this technical meeting. Perhaps, at our next meeting we can present some sound experimental data which will be a more substantial contribution to your program.

DIGESTER HANDLING SYSTEMS FOR KENAF

By William M. Herbert

Over the past ten years much commercial experience has been had in cooking such agricultural fibers as bagasse, straw, flax shives, esparto, bamboo, reeds, etc., to produce papermaking fibers. End products have ranged from insulation board to bleached pulps for fine writing and printing papers. There are no commercial installations for kenaf, but it is felt that the wide experience with similar materials could be extrapolated into recommended systems for kenaf.

This experience indicates that three major points must be considered:

1. A system concept must be employed. In other words, the digester system must start at the reclaiming of stored material and be carried through to the blow tank.

2. Laboratory work indicates that kenaf will respond well to high speed cooking techniques developed for the other agricultural fibers. This means the digester itself may be designed for 10 to 20 minutes cooking with alkaline processes, with the attendant advantages of excellent control and pulp uniformity.

3. The reported mill trial [G. W. Guttry, Hudson Pulp and Paper Corporation] with green kenaf showed up many of the problems associated with pulping green bagasse. The problems of slow drainage, excessive foaming, sticking, and related difficulties are almost completely eliminated when the bagasse is aged for two to three months or more. Hence, it is believed that continuing efforts should be made to determine optimum methods of storing the kenaf, with particular emphasis on bulk storage.

The growing shortage of hardwoods in many areas indicates that the immediate future for kenaf lies in the small, 50 to 100 ton/day satellite pulp mill, attached to the large integrated mill that has a need for short fibers. The designs for this size pulp mill are completed and proven in many installations around the world.

The principal problems have been in the handling and cleaning systems, from the storage area to the digester. These materials will assume a negative angle of repose upon the slightest provocation. The bulk density will

vary with real time, and storage conditions. Commercially harvested materials contain large quantities of extraneous, undesirable materials - stones, sand, machete blades, baling wire, and similar items. For a successful operation, these factors must be recognized in the design of the conveying and metering systems for the raw material.

Many types of conveyors can be and are being used successfully. Transfer points, chutes and bins should have diverging, not converging sides, should be at steep angles - 30° or less from the vertical. Bins of any significant capacity should have live bottoms.

The system used depends upon the method of storage chosen. With bulk storage of kenaf cut green by a forage harvester, we would recommend the following:

1. Reclaim from the pile with a bulldozer or similar equipment.

2. Sluice through a flume, where heavy materials and sand can be settled.

3. Extract from flume with a drainer conveyor, when additional washing may be accomplished.

4. Extract additional moisture in a screw or similar press to attain 30-35% O.D. solids.

5. Store pressed material in a live bottom surge bin, 20-30 min. running capacity.

6. Extract from surge bin with apron conveyor having pins and variable speed drive. Properly designed, this unit becomes the raw material meter to the digester.

7. Convey to digester. Slat, belt or screw conveyors may be used. Choice is determined more by elevation and economic considerations, rather than by process requirements.

8. A compression-type screw feeder into the digester would normally be recommended, because of its simplicity, relatively low maintenance considering abrasive nature of the raw material, and because moisture content will be further reduced, up to 50% O.D. solids, with attendant steam economy and increased solids content of the black liquor.

If the material is stored in bales, then a Hydrapulper or similar device would be recommended to break up the bales, thoroughly wet the material, break loose pith and sand, and separate large foreign objects. Thereafter the system would be about the same as above.

Methods have been developed to convey and clean by pneumatic equipment material that is harvested dry, and stored in bale form such that the material remains dry - climate, protection, etc. This would consist of:

1. A bale breaker.

2. Air classification to remove light fines - dust.

3. Screening to remove heavy fines - sand.

4. An air jump to separate heavy foreign objects.

5. A live-bottom metering bin, similar to above.

6. A twin-paddle mixer to add moisture or liquor ahead of digester.

This dry system is in operation in several mills, but is not considered as desirable as the wet handling system. The wet systems are more effective in removing dirt and pith, although the pulp quality is approximately the same. If the raw material becomes wet in storage, plugging problems may be encountered in pneumatic systems, and efficiency of the cleaning equipment drops off.

The dry systems are less costly, and are recommended for lower tonnage installations, when careful harvesting and storage methods are known to exist.

In summary,

1. A system separate and distinct from the wood cooking facilities should be employed.

2. Continuous, rapid digestion is indicated.

3. The handling system to the digester should be carefully designed to provide a continuous, controlled flow of well cleaned material.

KENAF STUDIES AT EASTEX

Notes on Remarks of Wayne Robinson*

1. One and one-quarter acres were planted in 1966 with 30-in. row spacing and 10-12 in. seed spacing using sorghum planting practice. In September stalks were 8 to 9 ft. tall. After frost the stalks stood in the field until harvest in mid-November. Stalks were chopped in a silage cutter.

2. The chopped material was pulped at 335°F in an upright laboratory digester (2 cu. ft. capacity) using direct steam. Hardwood pulping conditions were applied, including a total time of 2 hours with a rise of 30 min. and a liquid-solid ratio of 3.1 to 1.0. A permanaganate number of 14 was the aim. Sulfidity was 24-25%.

3. The digester was blown and no defibering was necessary. The screened yield (8-cut) was 42% and the rejects were 2.7%, basis original moisture-free material. (The laboratory digester customarily gives higher rejects than the mill digesters.)

4. The beater test of the kenaf pulp at 400 ml showed the kenaf pulp to take one-quarter of the beating time of hardwood and one-eighth the time of pine pulps. The Mullen was poorer than mill hardwood pulp and significantly lower in tearing strength.

5. The pulp was bleached to 81 and 87% with a CEHD sequence similarly to hardwood pulps. The viscosities were 16.5 and 10.0 c.p. respectively.

6. Another crop was planned.

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* Prepared by J. N. McGovern.

VARIETAL TESTS AND HARVESTING DEMONSTRATION

Agronomy Department, University of Florida

G. B. Killinger, In charge

These demonstrations took place on the lands of the Beef Research Unit, University of Florida. Eleven varieties listed below were being grown on a Leon fine sand soil.

Everglades 41	Cuba 2032
Everglades 71	* Cubana
* BG-52-75	G-4
* BG-58-10	G-45
Cuba	* PI 305080 (Russia)
	Salvador 79

All varieties except Salvador 79 were being grown in plots with row spacings of 19 and 38 in. and in four replications. Each plot consisted of four rows. Plantings of 19-in. row spacings were on flat land; those of 38-in. spacing were bedded. Planting date was April 27. When harvested, the yields of oven-dry stems from the 19-in. row spacings on flat land ranged from 12,949 to 21,399 lb. per acre. From the trials with 38-in. row spacings on bedded land, the yields of oven-dry stems ranged from 10,435 to 19,913 lb. per acre.

In a second plot, seven varieties plus a mixture of kenaf and Urena lobata were being grown. Of the varieties listed above, only those without asterisks were planted. The amount of kenaf planted here varied from one to 12 rows of a single variety. Soil preparation was as follows:

> The soil was plowed and harrowed to a seedbed. In March 800 lb. per acre of 8-8-8 fertilizer was broadcast and then the field was bedded. On April 5 the kenaf was planted at a seeding rate of 6 lb. per acre. On May 8, 200 lb. ammonium nitrate and 100 lb. potassium chloride was applied and on June 27 another 200 lb. per acre of ammonium nitrate was applied. Total fertilizer applied is shown below:
>
> Nitrogen = 196 lb.
> P_2O_5 = 64 lb.
> K_2O = 124 lb.

Yields of oven-dry stems from these seven varieties ranged from 17,428 to 33,973 lb. per acre.

A third area consisted of plots comprising 12 rows each of G-4, E-41 and 71. Planting was performed on April 27. Fertilizer was applied three times. The day before planting 100 lb. per acre of 8-8-8 fertilizer was applied. On June 7 the application consisted of 300 lb. ammonium nitrate and 200 lb. potassium chloride. Later, on June 26, ammonium nitrate was added to the extent of 200 lb. Total fertilizer applied is shown below:

Nitrogen	=	245 lb.
P_2O_5	=	80 lb.
K_2O	=	200 lb.

Many stalks in these plantings had reached heights of 20 ft.

The harvesting demonstration was supervised by Dr. G. E. Van Riper, manager, Agronomy Department, Deere and Company, Moline, Illinois. An unmodified forage harvester-cutter JD-38 drawn by a JD 4020 tractor was used. Many stalks were 20 ft tall and had basal diameters greater than 1-1/2 in. Stalks were chopped into pieces of about one-half inch length. Two typical scenes from the harvesting demonstration are shown in Figs 1 and 2.

Fig. 1. Harvesting 20-ft. kenaf stalks at Gainesville, Florida, November 1, 1967.

Fig. 2. Harvesting kenaf with an unmodified, tractor-drawn forage harvester-cutter. Chopped kenaf is blown directly into a four-wheeled, highside, bulk trailer.

KENAF PULPING DEMONSTRATION

Pulp and Paper Laboratory, Department of Chemical

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W. J. Nolan, In charge

November 1, 1967

This demonstration was conducted with fresh green kenaf of variety Everglades 41 grown by the Agronomy Department of the University. The stalks, 16 feet long after removal of tops, were cut with a band saw into pieces of 1-in. length. A substantial portion of the cut pieces were then shredded in a Vertiflex attrition mill with a clearance of 1 in. between spiked tooth plates. Both shredded material and cut pieces were used in the pulping demonstration. The Laboratory's six-chamber digester was used. Each chamber was charged with 1000 g kenaf material (moisture-free basis). Sufficient water and chemicals were added to provide a liquid-solids ratio of 7:1 and a chemical concentration of 16% active alkali (as Na_2O), basis kenaf solids, with a sulfidity of 25%. After cooking for various periods at 110 psi the contents of the digestion chambers were blown at full pressure into a cyclone collector. Results of pulping are presented in Table I.

Pulps from cooks No. 4108 and 4109 were screened on an 8-cut flat screen and then dewatered on a 125-mesh screen. Filtrate from the screening showed a faint cloud of fine material or pith. With this partial removal of pith, the freeness of the filtered pulp No. 4109 was 450 ml CSf. Pulp No. 4110 was not passed over the flat screen so that no fine pith was lost. This accounts for the 50 ml lower freeness in the case of pulp No. 4110. The amount of pith lost in screening is only a small fraction of the pith in the pulp. This method of pith removal would not be practical in any industrial application.

Visual examination of dilute suspensions of the blown pulp in 2-liter cylinders showed an accumulation of fine material at the top as the fibers settled to the bottom. This floating material was attributed to pith which would account for the low freeness values observed for these pulps.

Washed pulp from cook No. 4110 was characterized after refining to various degrees in a standard beater. With the exception of handsheet size, the techniques met the requirements for TAPPI Standards. Handsheets were 7-3/4 in. in diameter. Results of the beater evaluations are summarized in Table II.

Table I. Sulfate Pulping of Fresh Green Kenaf

Cook No.	Condition of kenaf	Cooking time, total, min[a]	Pulp yield, % Total	Pulp yield, % Screened	Screenings, %	Lignin in pulp, %	Equivalent K No.	Freeness, CS, ml
4108	Shredded	30	57.4	19.6[b]	64.1	-	-	-
4109	Shredded	45	49.4	49.1[b]	0.7	2.2	14.6	450
4110	Shredded	55	51.3	51.3	0.0	1.3	8.7	400
4112	Shredded	65	49.1	49.1	0.0	-	-	-
4113	Shredded	70	48.6	48.6	0.0	-	-	-
4111	1 in. pieces	56-3/4	50.0	44.9	10.2	-	-	-

a/ Total time includes the 30-min period to reach maximum steam pressure.

b/ Passed over 8-cut flat screen then dewatered on 125 mesh screen.

Table II. Physical and Strength Characteristics of Kenaf Sulfate Pulp No. 4110 at Several Stages of Beating[a]

Beating time, min	Freeness, CH, ml	Basis weight, gsm	Breaking length, m	Burst factor, $(g/cm^2)/(g/m^2)$	Tear factor, $g/(g/m^2)$	Bulk, cm^3/g
0	395	77.9	8010	50.3	127.4	1.43
4	344	79.5	8480	53.6	109.6	1.34
8	313	76.0	9330	60.0	102.7	1.27
13	239	79.2	8690	63.2	83.2	1.22
18	188	77.0	9410	65.6	78.8	1.12

a/ Handsheet prepared with a 7-3/4 in. Valley sheet mold.

Resolution

Adopted by conferees on November 1, 1967

The following resolution was passed by the participants in the Kenaf Conference held October 31 and November 1, 1967, at Gainesville, Florida. The Conference was sponsored by the Technical Association of the Pulp and Paper Industry in cooperation with the University of Florida Agricultural and Engineering Experiment Stations and Center for Tropical Agriculture.

1. Kenaf is a new raw material for the pulp and paper industry that has definite agricultural, technological, and economic potential for development into a crop of importance for the United States.

2. Full realization of kenaf's possibilities in a reasonable time period requires a considerable acceleration of research efforts, including:

(a) Production research on problems such as selection and breeding to achieve nematode and disease resistance, and maximum yields per acre of kenaf varieties particularly adapted for use by the pulp and paper industry.

(b) Utilization research to seek optimum processing procedures for kenaf, including investigation of continuous pulping processes, and the development of improved pulping, bleaching and refining methods for kenaf pulps.

(c) Agricultural engineering research to develop improved procedures for harvest, handling, transportation, and storage of kenaf.

3. The U.S. Department of Agriculture should substantially expand its research program on kenaf along the above lines to complement research being carried out by industry and by State Agricultural Experiment Station workers.

4. Copies of this resolution should be sent by the Chairman of the Conference to the following:

The Secretary of Agriculture

The Executive Secretary of the USDA's Utilization, Research and Development Advisory Committee

The Administrator of the USDA's Agricultural
Research Service

The Agricultural Research Services
Deputy Administrators for Farm Research
and for Nutrition, Consumer, and Industrial
Use Research.

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